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NATIONAL DAM SAFETY PROGRAM. PINE TREE LAKE EAST DAM (MO 30992)--ETC(U)
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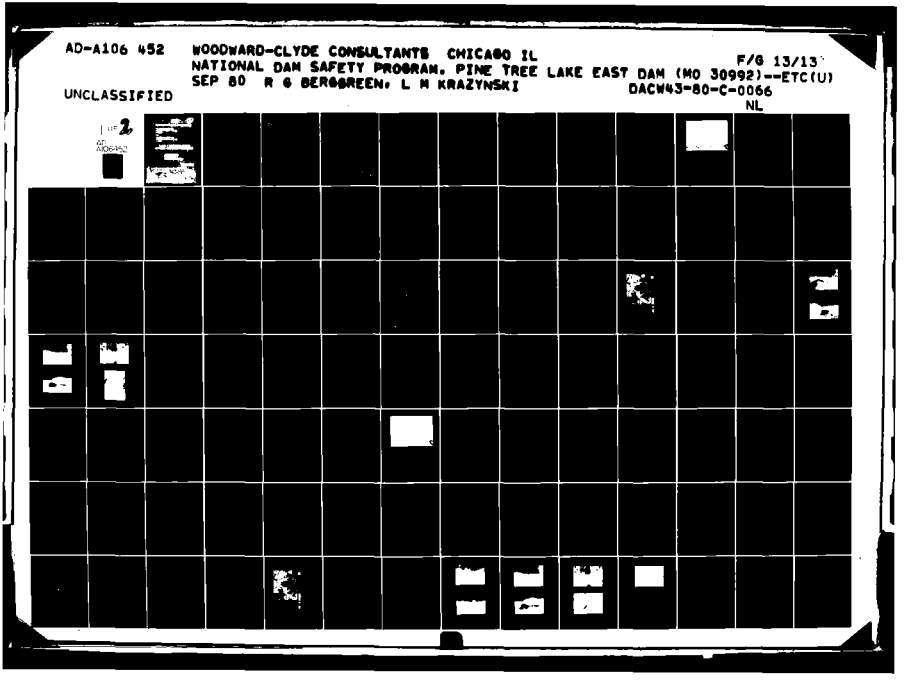

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-PD

SUBJECT: Pine Tree Lake East Dam (MO 30992) and Pine Tree Lake West Dam (MO 30995) Phase I Inspection Reports

These reports present the result of field inspection and evaluation of Pine Tree Lake East Dam (MO 30992) and Pine Tree Lake West Dam (MO 30995), Washington Country, Missouri.

It was prepared under the National Program of Inspection of Non-Federal Dams.

These dams have been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

a. The common spillway for MO 30992 and MO 30995 will not pass a 10-year frequency flood without overtopping MO 30992 dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

b. Overtopping of either dam could cause failure.

c. Failure of either dam significantly increases the hazard to life and property downstream.

Pine Tree Lake West Dam will be overtopped by a 10-year frequency flood, however, Pine Tree Lake East Dam will not be overtopped as a consequence of overtopping of Pine Tree Lake West Dam. Since these dams share a common spillway, this spillway is judged unusually small and seriously inadequate for both dams.

SUBMITTED BY: SIGNED
Chief, Engineering Division

15 DEC 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

16 DEC 1980
Date

PINE TREE LAKE EAST DAM

Washington County, Missouri

Missouri Inventory No. 30992

Phase I Inspection Report

(6) **National Dam Safety Program.**

Pine Tree Lake East Dam (MO 30992),
and Pine Tree Lake West Dam (MO 30995),
Mississippi - Kaskaskia - St. Louis Basin,
Washington County, Missouri. Phase I
Inspection Report.

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

(9) Final rept.,

(15) DACW43-80-C-0066

(10) Richard G. /Berggreen
Leonard M. /Krazynski

Under Direction of

St Louis District, Corps of Engineers

(12) 104

for

Governor of Missouri

(11) Sep[redacted]80

"Original contains color plates: All DTIC reproductions will be in black and white"

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Pine Tree Lake East Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of North Fork, Fourche a Renault
Date of Inspection	23 June 1980

Pine Tree Lake East Dam, Missouri Inventory No. 30992, was inspected by L. M. Krazynski (geotechnical engineer), R. Juyal (hydrologist) and J. B. Stevens (geotechnical engineer). The dam is an earth dam used for recreational purposes.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification based on available data and a visual inspection of those dams which might pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District Corps of Engineers (SLD) has judged this dam as having a high hazard potential. SLD has estimated the potential downstream hazard zone to extend two miles downstream. Immediately below the dam, there are several occupied structures where loss of life and property damage could occur in the event of failure.

The dam is classified as a small size dam due to its 33 ft height, and its storage capacity of 63 ac-ft. Dams within the small size classification have heights between 25 and 40 ft or storage capacities between 50 and 1000 ac-ft.

Our inspection and evaluation indicate the dam is in generally poor condition. The principal reason for this judgment is the small spillway capacity. No evidence of instability of the embankment was observed at the time of our inspection. The slopes and

crest of the dam have a thick grass cover with scattered brush and small trees, except in the roadway. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for the Safety Inspection of Dams" were not available.

Hydrologic/hydraulic studies indicate that a one percent probability-of-occurrence event (100-yr flood) will result in overtopping of the dam. The 10 percent probability-of-occurrence event (10-yr flood) will not overtop the Pine Tree Lake East Dam, but the Pine Tree Lake West Dam embankment will be overtopped for the 10 percent probability-of-occurrence event. The two dams share a common spillway and the two reservoirs are only partially separated by a ridge. If Pine Tree Lake West dam were to fail, a portion of the storage of Pine Tree Lake East Dam would be released. Our analyses further indicate that the Pine Tree Lake East Dam will be overtopped for a hydrologic event which produces greater than 17 percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

It is recommended that the following remedial measures and additional studies be undertaken for the Pine Tree Lake East Dam:

1. Design and construction of a spillway system with the capacity to pass 100 percent of the PMF. The PMF is the recommended spillway design flood, due to the number and proximity of the downstream residences. Potential failure of this dam is judged to represent a significant hazard for loss of life and property. The design of the new spillway system should also consider the location, size and erodibility of the downstream discharge channel. Potential for significant erosion at the toe of the dam should be minimized. Consideration should also be given to the removal (or re-design) of the existing wooden bridge crossing the existing spillway, to avoid the risk of obstructing the spillway or the discharge channel during flood flows.

It may be possible to design the new spillway system for a design flood of less than 100 percent of the PMF, if it can be demonstrated by the more detailed

hydraulic/hydrologic study that with minimal potential overtopping of small depth and duration the hazard to the downstream residents and property can be minimized to an acceptable level.

2. Repair, if needed, to the low level discharge pipe and valve at the toe of the dam.

3. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed for appropriate loading conditions (including seismic) and made a matter of record.

4. Evaluation of available options for an effective and practical warning system is recommended, to alert downstream residents should potentially hazardous conditions develop at the dam.

A program of periodic inspections and maintenance should be implemented for the dam and appurtenant structures. This program should include but not be limited to the following:

1. Inspection of the embankment to identify any signs of slope stability such as slumping or cracking, and/or possible future development of seepage through the dam embankment.

2. Periodic inspection of slope vegetation to determine the need for removal of detrimental trees and brush.

3. Inspection of the outlet pipe for evidence of leakage or piping adjacent to the pipe.

4. Inspection of the discharge channel for evidence of serious erosion due to continued outflow.

Records of inspections and recommended and performed maintenance on the facilities should be kept. All inspections and maintenance should be done under the guidance of an engineer experienced in the design and construction of earth dams.

It is recommended that the owner take action immediately on the recommendations concerning the design and construction of an adequate spillway system. Action on other recommendations should be taken without undue delay.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

Leonard M. Krazynski, P.E.
Vice President

OVERVIEW

PINE TREE LAKE EAST DAM

MISSOURI INVENTORY NUMBER 30992

Pine Tree Lake East Dam on right side of photo; Pine Tree Lake West Dam on left side of photo.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
PINE TREE LAKE EAST DAM, MISSOURI INVENTORY No. 30992
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
PINE TREE LAKE EAST DAM, MISSOURI INVENTORY No. 30992

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Pine Tree Lake East Dam, Missouri Inventory Number 30992.

b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Pine Tree Lake East Dam is an earth dam constructed to form a recreational lake. An uncontrolled, concrete-lined spillway is located at the west end of the dam. This spillway also serves Pine Tree Lake West Dam (MO 30995). There is a low-level outlet pipe at the toe of the Pine Tree Lake East Dam. It consists of a 2.5-in. diameter PVC pipe and is controlled by a hand-operated valve near the exit point.

b. **Location.** The dam is located 5.3 mi WSW of Potosi, Washington Co, Missouri, in Sec 24, T37N, R1E, immediately north of Missouri Highway 8, on the USGS Potosi 7.5-minute quadrangle map. The dam is on an unnamed tributary of the North Fork, Fourche a Renault.

c. **Size classification.** The dam is classified as small due to its 33 ft height and 63 ac-ft storage volume. The small size classification is determined on the basis of either a height between 25 and 40 ft or a storage volume betwen 50 and 1000 ac-ft.

d. **Hazard classification.** The St Louis District, Corps of Engineers has classified this dam as having a high hazard potential; we concur with this classification. The estimated hazard zone extends 2 mi downstream of the dam. There are several occupied residences and Missouri Highway 8 located within 0.5 mi of the dam. Loss of life and property damage could be significant in the event of dam failure.

e. **Ownership.** We understand the dam is owned by A.M. Enterprises, 10 Meadowbrook Country Club Est., Ballwin, Missouri 63011. Correspondence should be addressed to the attention of Mr Eugene Alper.

f. **Purpose of dam.** The impoundment is used for recreational purposes.

g. **Design and construction history.** According to Mr Eugene Alper the dam was constructed in 1975. There was no specific design for the dam but guidelines for small dams published by the Missouri Conservation Commission were reportedly followed. Soil for the dam was obtained from the present lake area and placed with a dozer and scraper. The fill was compacted only with this equipment; rollers were not used. It is our understanding that the spillway was not designed by an engineer.

h. **Normal operating procedures.** No operating records were found. Flood flows pass over the uncontrolled spillway at the west end of the dam. No minimum or maximum operating pool elevations are apparently maintained.

1.3 Pertinent Data

a. **Drainage area.** Approximately 0.15 mi^2 (This includes the area contributing to Pine Tree Lake West Dam (Missouri 30995) because the two reservoirs are connected and share one spillway).

b. **Discharge at dam site.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	52 ft^3/sec (at el 995.3)*
Total spillway capacity at maximum pool elevation	52 ft^3/sec (at el 995.3)*

c. **Elevation (ft above MSL).**

Top of dam	996.0 to 997.7
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	994.0
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	963.6

*At elevation over 995.3 ft, Pine Tree Lake West Dam is overtopped.

d. **Reservoir.**

Length of maximum pool	900 ft
Length of recreation pool	900 ft
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	52
Flood control pool	N/A
Design surcharge	N/A
Top of dam	63

f. **Reservoir surface (acres).**

Top of dam	6
Maximum pool	6
Flood-control pool	N/A
Recreation pool	5.5
Spillway crest	5.5

g. **Dam.**

Type	Earth fill
Length	567 ft
Height	33 ft
Top width	18 ft
Side slopes	Downstream 2(H) to 1(V); Upstream unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably homogeneous section of gravelly clay (CH))
Cutoff	Reported by owner to be 35-ft wide, 8-ft deep trench to bedrock backfilled with relatively rock-free clay
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating Facilities	N/A

i. **Spillway.**

Type	Trapezoidal, broad-crested, concrete weir
Width	6 ft at bottom, 18 ft at top
Crest elevation	994.0 ft
Gates	None
Upstream Channel	None
Downstream Channel	Earth, typically 8 ft wide, 4 ft deep

j. **Regulating outlets.** 2.5-in. diameter PVC pipe with valve at downstream end. No record of operation.

SECTION 2
ENGINEERING DATA

2.1 Design

No design plans or reports were found for Pine Tree Lake East Dam.

2.2 Construction

No construction records or data were found.

2.3 Operation

No records were found for maintaining a maximum or minimum operating pool elevation. No records were found documenting the operation of the valve and drain at the toe of the dam, nor was it reliably determined that the drain is in fact a functioning low level outlet for the lake.

There are no records of outflow at the spillway or of the history of the pool elevations.

2.4 Evaluation

a. **Availability.** The only engineering data obtained for this report was developed during the field inspection. No engineering design data or construction reports were found for this dam.

b. **Adequacy.** Insufficient data were available to determine the adequacy of the design.

Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These analyses should be performed for appropriate loading conditions (including earthquake loads and made a matter of record. These analyses should be conducted by an engineer experienced in the design and construction of dams.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site is located on the northern flank of the Ozark structural dome. The bedrock in the area is mapped as Ordovician age Gasconade Formation on the Geologic Map of Missouri (Fig 4). The Gasconade Formation is predominantly a cherty dolomite which varies from coarsely crystalline and very cherty at the top to finely crystalline with relatively small amounts of chert near the bottom of the formation. Caves and springs are common in this formation in the central Ozarks, but the field inspection did not identify any evidence of solution activity in the vicinity of the subject dam.

The soil at the dam site is a gravelly plastic residual clay (CH) developed on the Gasconade Formation. The site area is mapped on the Missouri General Soils Map as Captina-Clarksville-Doniphan Association.

Three faults or fault zones are mapped within 5 mi of the dam (Fig 4). The Shirley Fault Zone is mapped as approximately 8 mi in length, terminating less than 0.5 mi west of the dam. This fault is mapped as northeast side up. The Palmer Fault Zone, a complex network of short and long faults approximately 34 mi long is located approximately 5 mi south of the dam. The fault is mapped as down to the north. The Aptus Fault is located approximately 4 mi northeast of the dam. This fault has a mapped length of approximately 15 mi and is mapped as up to the northwest.

All of the faults in the vicinity of the dam are within Paleozoic age formations. There was no evidence of recent activity found and the area is not considered seismically active. The faults are likely Paleozoic in age and are not considered to pose an unusually high seismic hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was made of Pine Tree Lake East Dam on 23 June 1980 without an owner's representative present.

b. **Dam.** The dam was constructed with a gravelly, dark red, plastic clay (CH) obtained from the reservoir area. The gravel is an angular chert ranging in size from coarse sand to cobbles.

The slopes and crest of the dam have a thick grass cover with scattered small bushes and young trees except in the roadway. There is no riprap on the upstream slope and it is bare of vegetation to about the spillway elevation, which coincides closely with the discernible high-water mark. The erosion potential on the upstream face is judged to be low because of a short fetch contributing to wave action in the impoundment.

The vertical and horizontal alignment of the dam appear undisturbed. There is no evidence of sinkhole development, detrimental settlement, slides, depressions, cracking or animal burrows. No evidence of previous overtopping was observed.

No seepage through the earth embankment was observed at the time of our inspection. A small area upstream of the valve (Photo 6) was noted to be damp with a lush growth of grass.

c. **Appurtenant structures.**

1. Spillway. The spillway is a trapezoidal concrete weir, approximately 6 ft wide at the bottom, 18 ft wide at the top and having a height of about 1 ft at the top of concrete. A wooden bridge carries the road across the spillway but is not anchored to the dam in any way (Photo 2). The measured elevations at

the bottom of the wooden bridge girders is 994.9 and the average elevation of the spillway crest is 994.1 ft. There is only about 0.8 ft average clearance between the bottom of the bridge girders and the concrete spillway channel; hence, flows will be severely restricted. In the event of high water, the bridge may be moved downstream and there is a risk that it may become a significant obstruction to the flow of water in the spillway discharge channel. It may also divert the flow and cause serious erosion of the embankment. A concrete apron extends about 25 ft downstream from the spillway entrance. At the entrance is an open construction joint (Photo 2). Near the end of the apron, there is a 5-in. high concrete wall with the intended purpose of energy dissipation (Photo 4). Since there were no plans or records of construction available for review it is not known whether the concrete lining is adequately reinforced or whether a waterstop was provided for prevention of entry of water under the lining. Therefore, it is not known whether the spillway concrete lining will perform adequately from a structural standpoint during periods of heavy flow.

2. Low level outlet. The low level outlet observed at the toe of the dam consists of 2.5-in. diameter PVC pipe and is controlled by a protected valve located at the downstream end of the pipe. It is desirable and good engineering practice to locate the control valve upstream to eliminate permanent water pressure in the pipe beneath the embankment. The valve apparently has not been maintained and it was not operated by the inspection team for fear of possible breakage. It was not reliably determined that this is a functioning low level outlet.

d. **Reservoir area.** The reservoir is used for recreational purposes. There are several vacation homes on the slopes surrounding the reservoir. These slopes are heavily wooded, generally flatter than 4(H) to 1(V), and showed no signs of instability at the time of our visual inspection.

As the drainage area is heavily wooded, there apparently has been very little sediment transported into the lake.

e. **Downstream channel.** The downstream discharge channel (Photo 5) is typically 8 ft wide and 4 ft deep. It is cut into the natural ground, and is not protected against erosion. The soil is considered moderately erodible. Downstream from

a sharp bend at the end of the spillway apron, the channel heads in a southwesterly direction to join the natural stream channel about 400 ft downstream of Pine Tree Lake West Dam (MO 30995).

3.2 Evaluation

Our visual inspection indicates the dam and appurtenant structures are in generally poor condition. This judgment is based primarily on the small spillway size and the potential for obstruction and subsequent erosion in the spillway and discharge channel.

The spillway lining may not perform adequately during high flows. The bridge in the spillway may become an obstruction in the downstream channel and cause diversion of the flow and erosion of the embankment.

Our visual inspection did not find any sinkhole development, detrimental settlement, depressions, slides, cracking or other evidence of instability of the dam embankment. No animal burrows were noted. No evidence of previous overtopping was observed.

No seepage was noted from the embankment. At its present volume, the small seepage near low level outlet does not appear to endanger the safety of the dam.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level is controlled by the crest of the small ungated concrete spillway.

4.2 Maintenance of Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

The PVC pipe and valve, assumed to be a low level outlet from the lake, were not verified to be in an operative condition at the time of the inspection. No records were available on maintenance or operation of this outlet.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There are apparently no maintenance or operational procedures in effect. The lack of regular maintenance and periodic inspection is considered a deficiency.

The feasibility of a practical and effective warning system should be evaluated to alert downstream residents, should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic information was available for evaluation of the dam. Pertinent dimensions of the dam and reservoir were surveyed on 19 June 1980, measured during the field inspection or estimated from topographic mapping. The maps used in the analyses were the USGS Shirley and Potosi 7.5-minute quadrangle maps.

b. **Experience data.** No recorded history of rainfall, runoff, discharge or pool stage data were available for this reservoir or watershed.

c. **Visual observations.** At the time of inspection, the spillway was crossed by a wooden bridge which derives it support from the spillway sides. The bridge is not anchored and is apparently intended to be removed by the water in the event of high spillway flow. In these circumstances the dislocated bridge may create an obstruction in the spillway or discharge channel. No other conditions were noted which could lead to a reduced spillway capacity during a flood occurrence. Other observations regarding the reservoir, spillway and dis charge are given in Section 3.

d. **Overtopping potential.** The overtopping potential of Pine Tree Lake East Dam was calculated considering the effect of the adjoining Pine Tree Lake West Dam. The two dams share a common spillway between the two embankments and a common drainage basin. The reservoirs of the two dams are connected by a canal of undetermined depth. The canal crosses a natural ridge that partially separates the two reservoirs. The spillway is located along the south side of this canal.

For the overtopping analyses, the elevation of the top of the west dam was taken as 995.3 ft, a point on the crest of the dam to the west of the spillway. The elevation of the top of the east dam was taken as 996.0 ft, a point on the crest of the dam to the east of the spillway. As the reservoir water surface

rises, the east and west dams are overtopped at the respective elevations noted above. Therefore, when the east dam is overtopped, the total outflow includes the flow through the concrete-lined spillway plus outflow over the west dam crest adjacent to the spillway.

Hydraulic/hydrologic analyses indicate that the Pine Tree Lake East Dam will be overtopped by the one percent probability-of-occurrence event. It should be noted, however, that Pine Tree West Dam will be overtopped by the 10 percent probability-of-occurrence event because the point of overtopping for the west dam is at an elevation lower than the east dam. If Pine Tree Lake West Dam were to fail as a result of overtopping, a portion of the storage of Pine Tree Lake East Dam would be released. Our analyses further indicate that a storm which produces greater than 17 percent of the Probable Maximum Flood (PMF) will cause overtopping of the east embankment. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in in the region.

The following table presents the expected severity of overtopping for various precipitation events:

Percent PMF	Maximum W.S. Elev., ft, MSL	Max. Depth Over Dam, ft	Max. Outflow, ft^3/sec	Duration of Overtopping, hrs
17	996.0	0	120	0
50	996.7	0.7	455	4.7
100	997.0	1.0	920	6.5

Overtopping and failure of this dam in its present condition could pose serious danger to the residents and property located in the downstream hazard zone. Although the depth and duration of overtopping for the east embankment is not exceptionally extreme for the 50 or 100 percent PMF events, it should be recognized that during the periods of heavy flow erosion may widen and deepen the existing discharge channel, undermining the toe of the dam. This could cause a dam failure. Therefore, it is recommended that the spillway system design flood be 100 percent of the PMF. More detailed studies such as

erosion potential studies of the embankment soils and inundation studies of the downstream channel may justify designing the spillway system to a design storm less than the PMF. These studies are beyond the scope of this Phase I report.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** The visual inspection of the Pine Tree Lake East Dam revealed no evidence of horizontal or vertical displacement of the dam crest alignment. Cracking, detrimental settlement, slides, depressions or other signs of instability were not observed. No free-flow seepage on the downstream slope or at the toe was observed. The vegetation cover on the crest and slopes consists of thick grasses with a few small trees and bushes. The vegetation does not appear to represent a hazard to the safety of the dam at this time.

The soil used to construct the dam is not considered to have a high liquefaction potential. The erodibility of the embankment soils on the downstream slope is judged to be low due to thick vegetation. This grass cover may be partially removed causing the dam to have a higher erosion potential, if subject to flow velocities greater than 5 ft/sec.

b. **Design and construction data.** No design or construction data were available for this dam and spillway. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available.

c. **Operating records.** No operating records or water level records are maintained for this facility.

d. **Post construction changes.** The lack of drawings or construction reports precludes the identification of post construction changes. However, there were no obvious changes observed.

e. **Seismic stability.** The dam is Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction is unlikely during a moderate seismic event. However, since no static stability analysis is available for review, the seismic stability cannot be properly evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, Pine Tree Lake East Dam appears to be in generally poor condition. The primary reason for this judgment is the low capacity of the existing spillway. The dam is overtopped for the 1 percent probability-of-occurrence event or for storms greater than 17 percent of the PMF. Pine Tree Lake West Dam is overtopped for the 10 percent probability-of-occurrence event. If the west dam were to fail, a portion of the storage of the east dam would also be released, as the two reservoirs are only partially separated by a ridge. Based on our visual inspection, the dam earth embankment itself is judged to be a generally good condition, but seepage and stability analyses comparable to the requirements of the recommended guidelines were not available.

b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations in this Phase I report.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. This is considered a deficiency.

c. **Urgency.** The deficiencies described in this report could affect the risk of failure of this dam. It is suggested the recommendations concerning the design and construction of an adequate spillway system be implemented immediately to prevent the development of hazardous conditions. Action on other recommendations should be taken without undue delay.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete assessment of the safety of the dam. Those investigations which

should be performed immediately are described in Section 7.2b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent the storage of water.

2. Increase the height of dam and/or spillway size to pass the probable maximum flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Enhance the stability of the dam to permit overtopping by the probable maximum flood without failure.

5. Provide a highly reliable flood warning system (generally does not prevent damage but decreases the chances for loss of life).

b. **Recommendations.** Based on our inspection of the facilities at Pine Tree Lake East Dam, it is recommended that further study be conducted immediately to evaluate, as a minimum, the following topics:

1. Design and construction of a spillway system with the capacity to pass 100 percent of the PMF. The PMF is the recommended spillway design flood, due to the number and proximity of the downstream residences. Potential failure of this dam is judged to represent a significant hazard for loss of life and property. The design of the new spillway system should also consider the location, size and erodibility of the downstream discharge channel. Potential for significant erosion at the toe of the dam should be minimized. Con-

sideration should also be given to the removal (or re-design) of the existing wooden bridge crossing the existing spillway, to avoid the risk of obstructing the spillway or the discharge channel during flood flows.

It may be possible to design the new spillway system for a design flood of less than 100 percent of the PMF, if it can be demonstrated by more detailed hydraulic/hydrologic study that with minimal potential overtopping of small depth and duration the hazard to the downstream residents and property can be minimized to an acceptable level.

Additional topics, which should be addressed without undue delay, include the following:

2. Repair, if needed, to the low level discharge pipe and valve at the toe of the dam. Locating the valve which controls the low level outlet at the upstream end of the outlet pipe should be considered. It is generally good engineering practice to locate the valve upstream so that the water in the pipe beneath the earth embankment will not be continually under pressure.

3. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed for appropriate loading conditions (including seismic) and made a matter of record.

4. Evaluation of available options for an effective and practical warning system is recommended, to alert downstream residents should potentially hazardous conditions develop at the dam.

The recommended analyses and remedial measures should be done under the guidance of an engineer experienced in the design and construction of earth dams.

c. **O & M procedures.** A program of periodic inspections and maintenance should be implemented for the dam and appurtenant structures. The result of the inspections should be to identify and recommend necessary maintenance. This program should include but not be limited to the following:

1. Inspection of the embankment to identify any signs of slope instability such as slumping or cracking;

2. Periodic inspection of slope vegetation to determine the need for removal of detrimental trees and brush;

3. Inspection of the outlet pipe for evidence of leakage or piping adjacent to the pipe;

4. Inspection of the discharge channel for evidence of serious erosion due to continued outflow.

Records of inspection and recommended and performed maintenance on the facilities should be kept. All inspections and maintenance should be done under the guidance of an engineer experienced in the design and construction of earth dams.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, Missouri General Soil Map and Soil Association descriptions: US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, "National Program of Inspection of Non-Federal Dams".

Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, "National Program of Inspection of Non-Federal Dams".

Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1 inch equals approximately 8 miles (1:500,000).

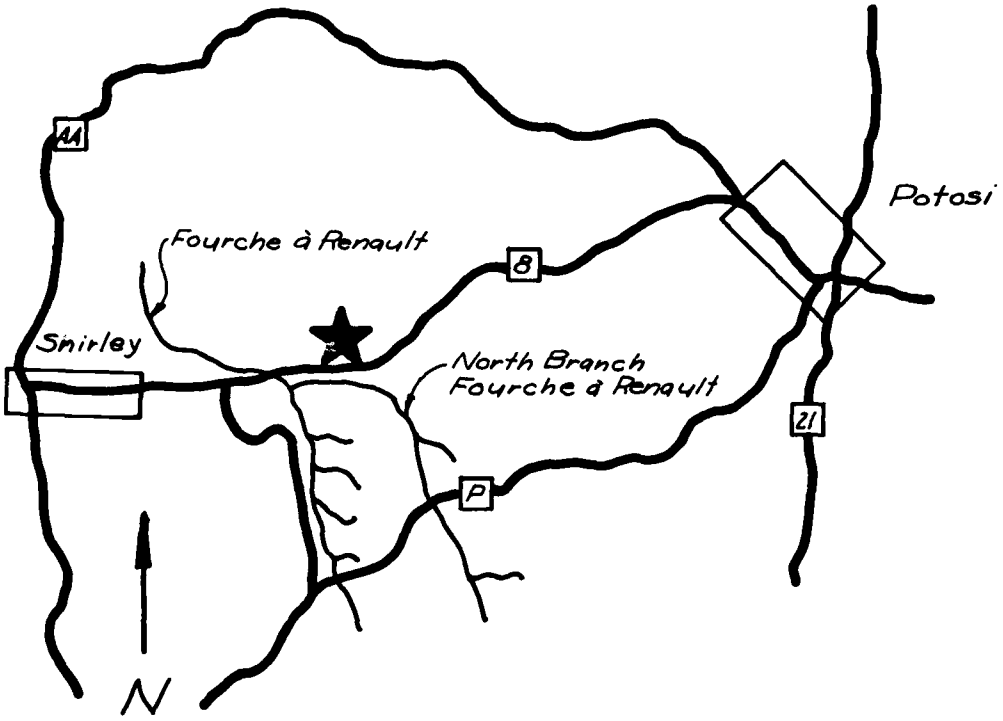
Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1 inch equals approximately 8 miles (1:500,000).

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.

Vicinity Map

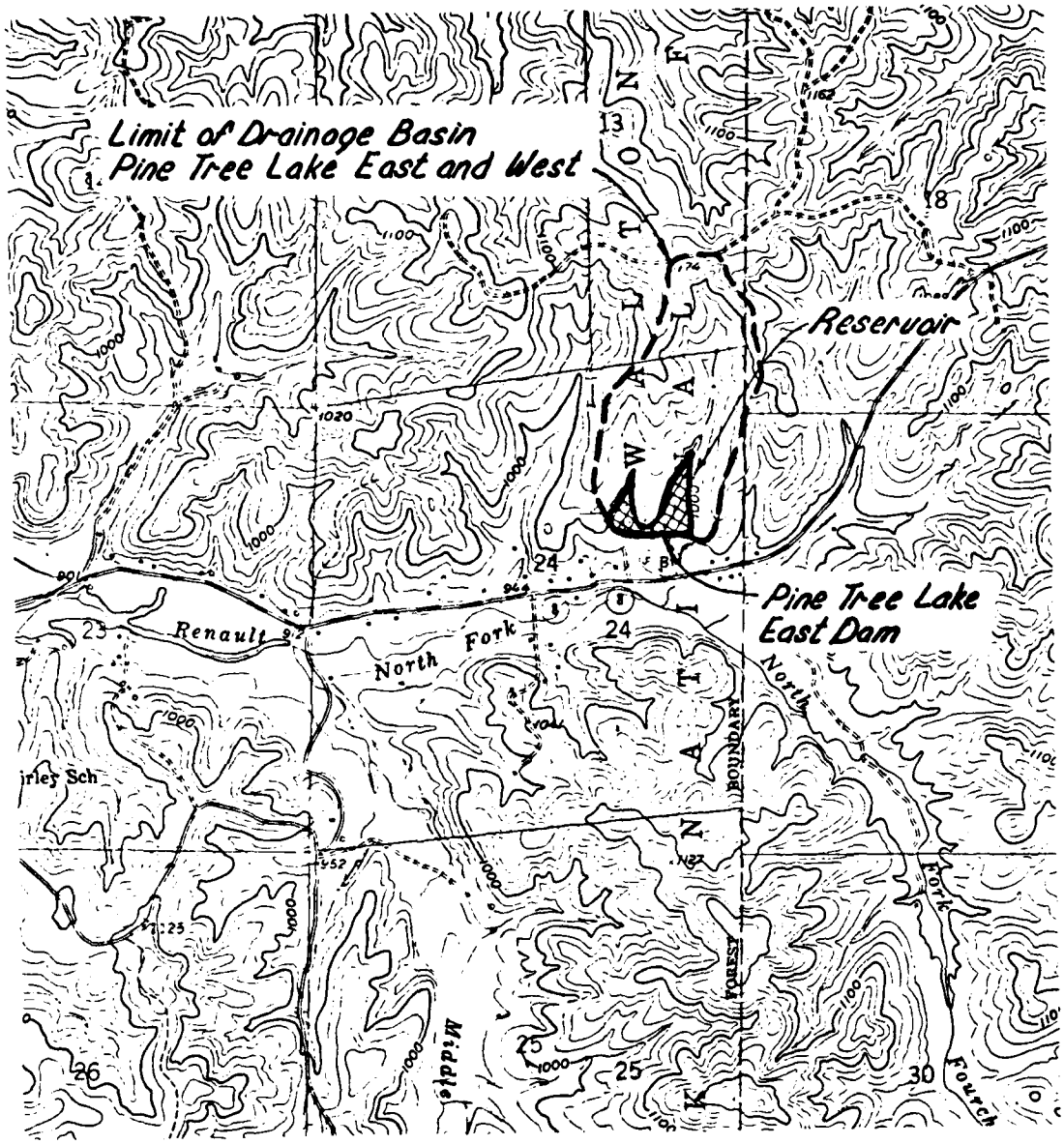


Scale, miles

Legend

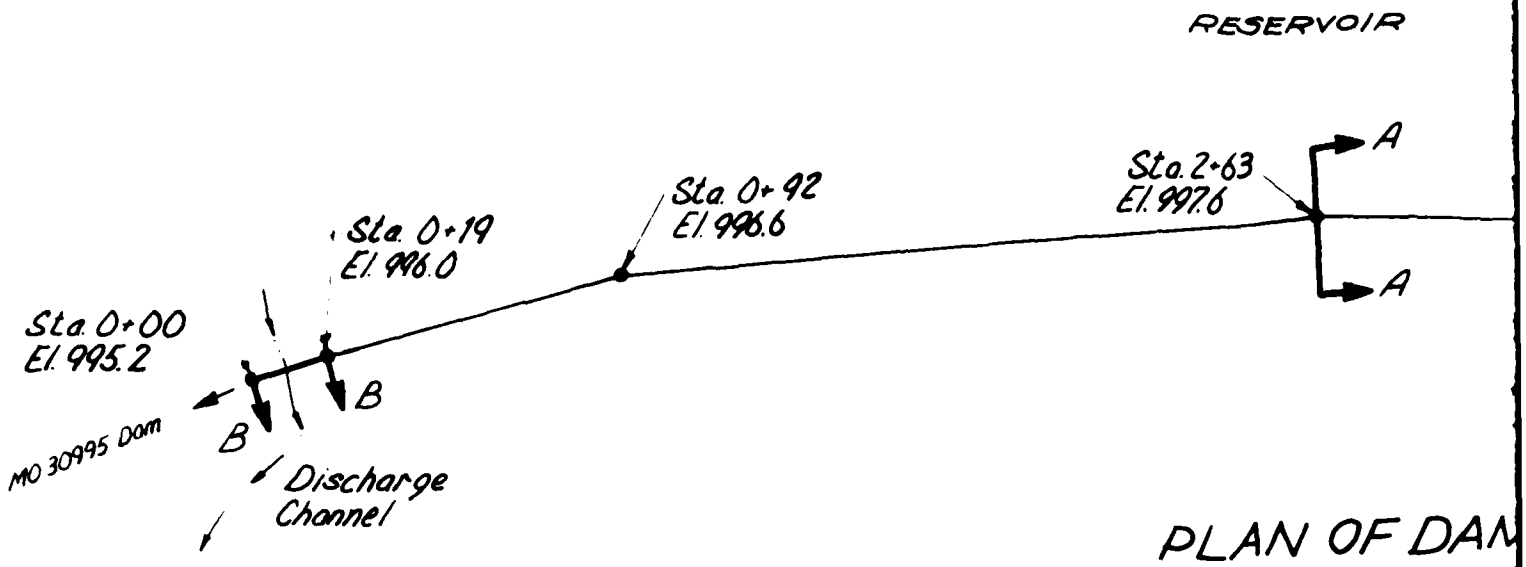
- County Line
- State highway and Route No.
- River or Creek
- City or Town
- Project location

SITE LOCATION MAP	
PINE TREE LAKE EAST DAM	
MO 30992	Fig. 1

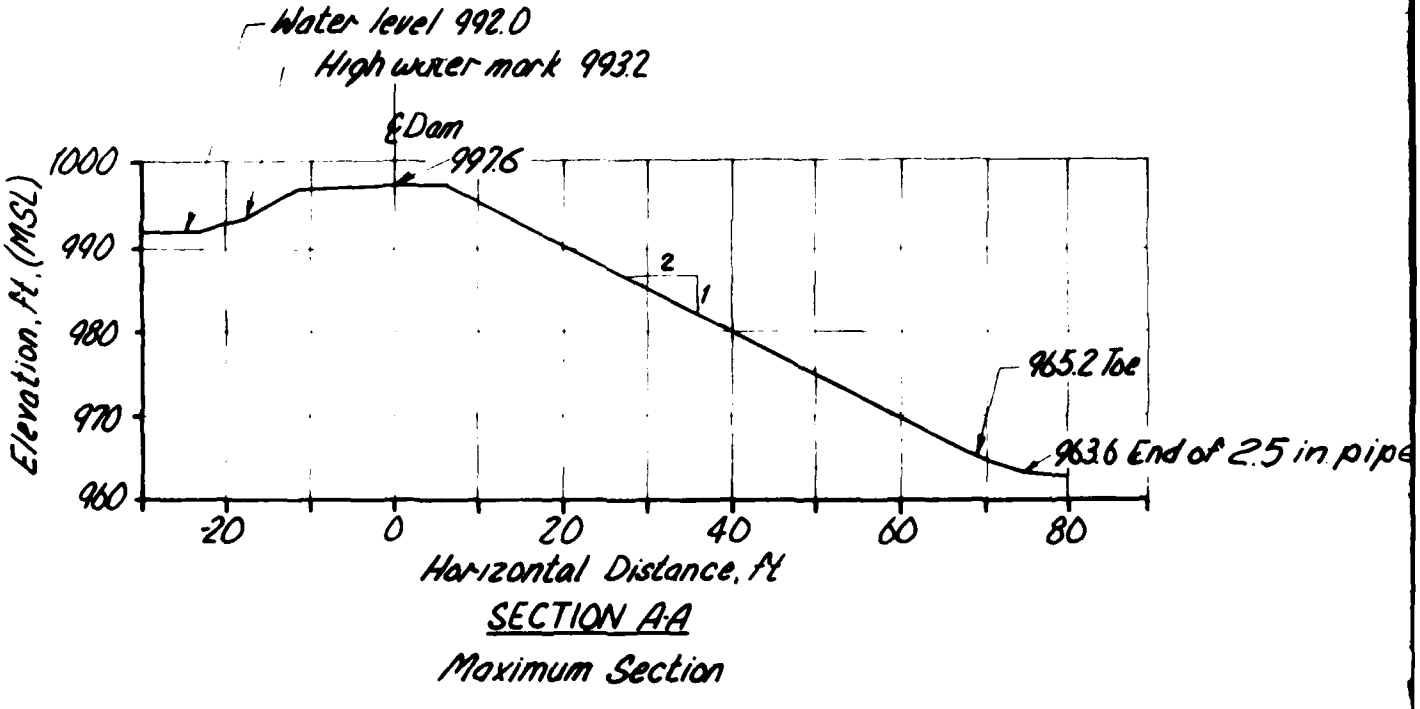


1. Topography from U.S.G.S. Shirley and Potosi 7½ minute quadrangle maps

DRAINAGE BASIN AND SITE TOPOGRAPHY	
PINE TREE LAKE EAST DAM	
MO 30992	Fig. 2



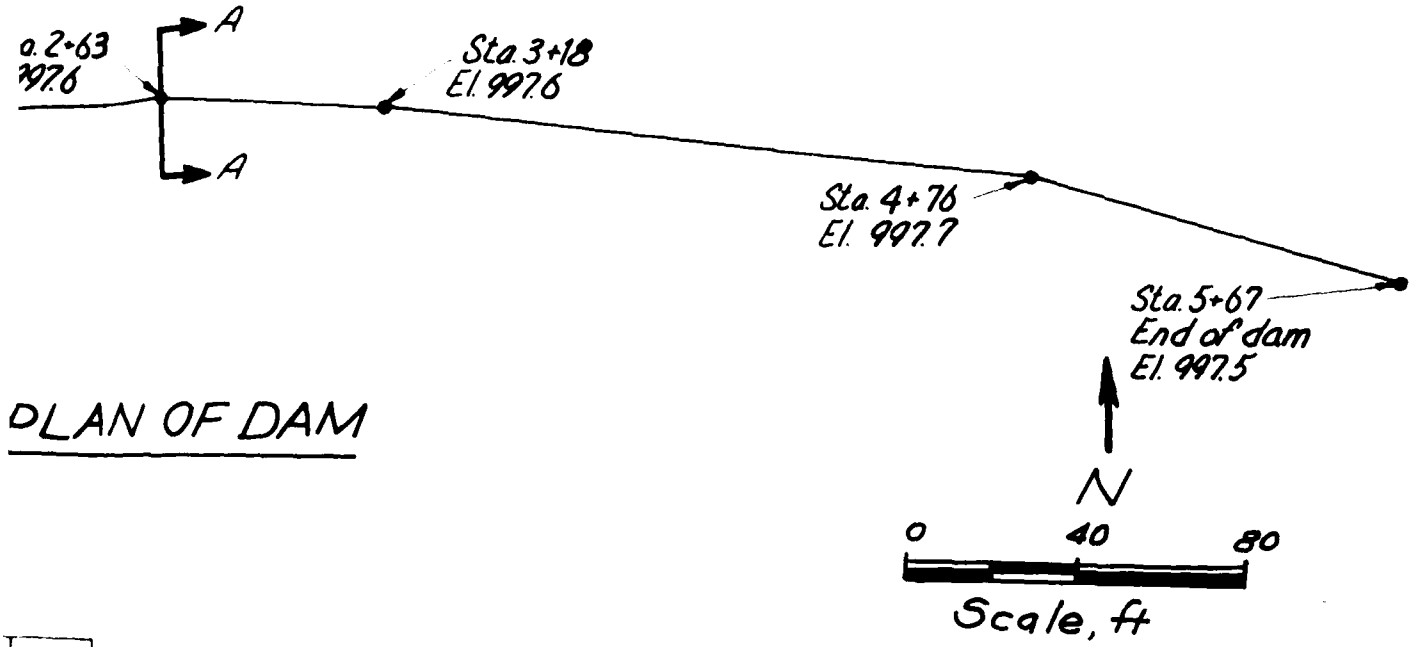
PLAN OF DAM



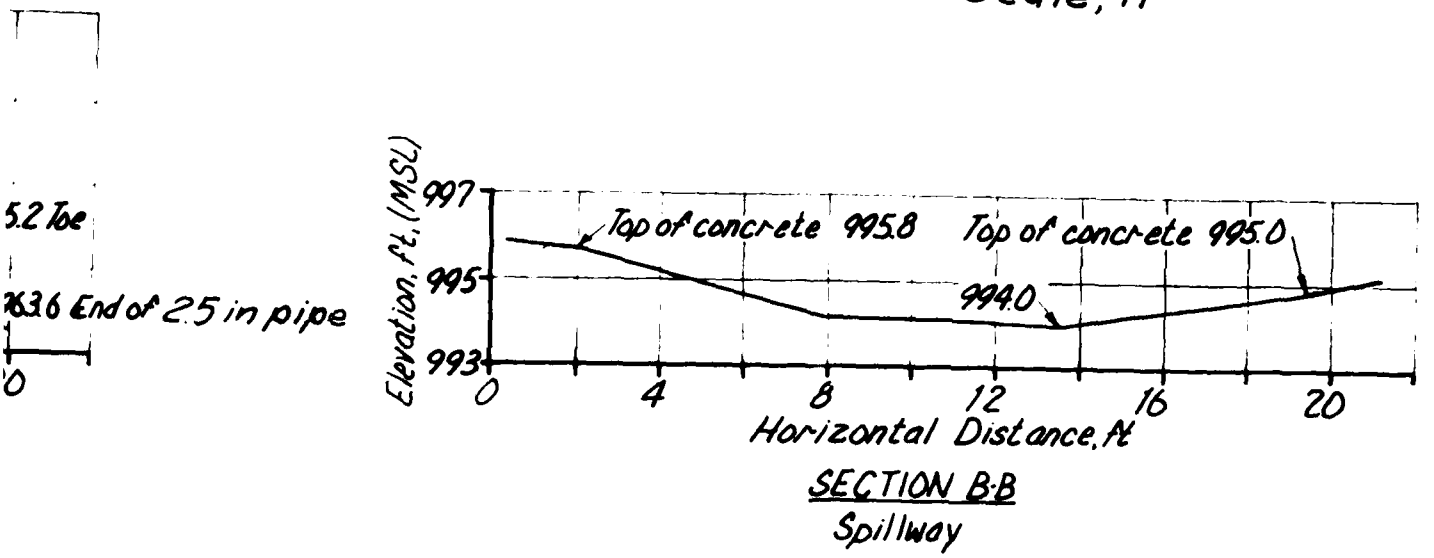
SECTION A-A

Maximum Section

RESERVOIR



PLAN OF DAM



SECTION B-B
Spillway

NOTES
1. Common spillway for MO30995 and MO 30992
2. Section B-B taken at North side of bridge

PLAN AND SECTION OF DAM AND SPILLWAY SECTION	
PINE TREE LAKE EAST DAM	
MO 30992	Fig. 8

Legend

- Or — Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- *Potosi Dolomite*
- Derby-Doerun Dolomite
- Davis Formation
- Ceb — Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

PINE TREE LAKE EAST DAM

MO 30992 | Fig. 4

APPENDIX A

Photographs

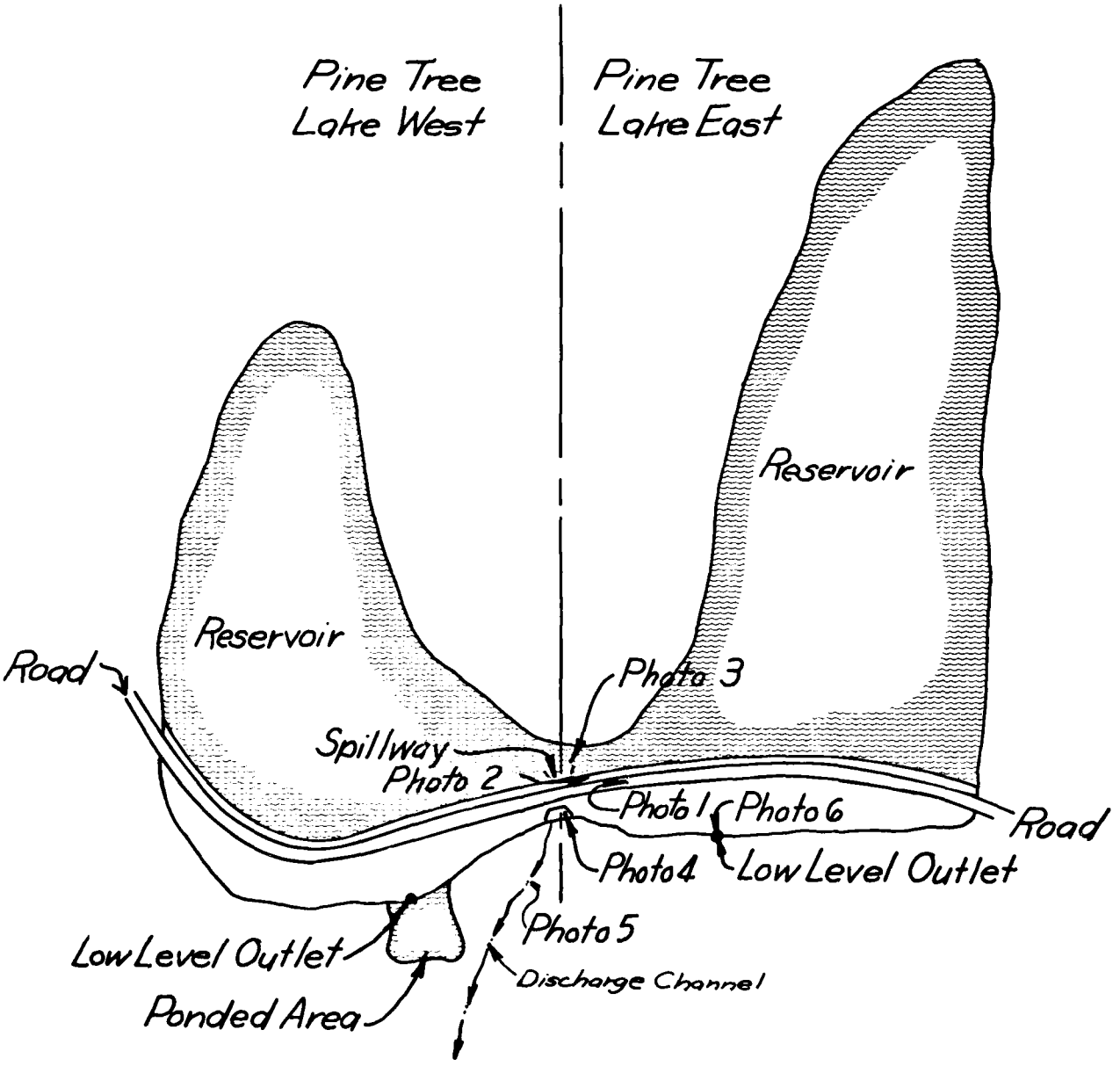


PHOTO LOCATION SKETCH	
PINE TREE LAKE EAST DAM	
MO 30992	Fig. A-1

1. View of downstream slope and crest looking east. Note thick grass cover on slope.

2. View of approach channel and upstream slope looking east. Note apparent lack of cutoff and open joint at spillway entrance.

3. Approach channel, spillway channel entrance and upstream slope.

4. View of spillway exit looking upstream. Bridge is not fixed and will float off with high flows. Note weir for energy dissipation.

5. Discharge channel looking upstream. Source of water undetermined.

6. Valve box for low level conduit at toe of dam.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}(s+1)^{0.7}}{1900\, Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_C \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_C = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF estimates and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - high water mark, el. 993.2

(2) Probable Maximum Storm - spillway crest elevation, el. 994.0

Because the low level outlet pipe is of small diameter, it was assumed that it was inoperable and did not pass any amount of the flood.

f. Spillway Rating Curve. The basic weir equation was utilized to compute the spillway rating curve. The weir equation is as follows:

$$Q = CLH^{3/2}$$

where Q = discharge in cubic feet per second
L = effective length of spillway in feet
C = coefficient of discharge (2.9)
H = total head over spillway in feet

B.2 Pertinent Data

a. Drainage area. 0.15 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.71 hrs

d. Hydrologic soil group. D

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 89
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 77

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Shirley and Potosi 7.5-minute quadrangle maps. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was computed by the intrinsic formula within the HEC-1 program, with pertinent spillway data entered on the $$ cards.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 994.0 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 993.2 ft, the elevation of the high water line in the reservoir area.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
```

```
     1  A1       DAM NO. 30992 AND 30995, PINE TREE LAKES, WASHINGTON COUNTY, MISSOURI.
     2  A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
     3  A3       PROBABLE MAXIMUM FLOOD RATIO FLOODS.
     4  B     288        0       10       -0       -0       -0       -0       -0       -0       -0
     5  B1      5
     6  J       1        4        1
     7  J1    .25      .50      .75     1.00
     8  K       0     0-IN                                                 1
     9  K1   PINE TREE LAKES PMF RATIO INFLOW HYDROGRAPHS.
    10  M       1        2    0.152                                    1                        1
    11  P       0      26.      102.     120.     130.     140.
    12  T                                                              -1      -89                      .051
    13  W2           0.713
    14  X      -2     -.05        5
    15  K       1      DAM                                                  1
    16  K1   PINE TREE LAKE PMF ROUTING AND OVERTOPPING ANALYSIS.
    17  Y                                        1        1
    18  Y1      1                                                    -994.0        0
    19  SA     0.      1.5      4.5      5.0      5.5      7.0     10.0
    20  SE   974.     980.     990.     992.     994.    1000.    1010.
    21  SS   994.      12.      2.9      1.5
    22  SD   996.     2.8      1.5
    23  SL     0.      33.     255.     475.
    24  SV 995.3     996.    996.5     997.
    25  K     99
```

Input Data
Various PMF Events
Pine Tree Lake East Dam
MO ID No 30992
B4

```
**********************************
*FLOOD HYDROGRAPH PACKAGE (HEC-1)*
*DAM SAFETY VERSION      JULY 1978*
*  LAST MODIFICATION  01 APR 80  *
**********************************

 RUN  DATE: 02 OCT 80
      TIME: 10.05.05

     DAM NO. 30992 AND 30995, PINE TREE LAKES, WASHINGTON COUNTY, MISSOURI.
     WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
     PROBABLE MAXIMUM FLOOD RATIO FLOODS.

                                JOB SPECIFICATION
        NQ     NMHR     NMIN     IDAY     IHR    IMIN    METRC    IPLT    IPRT   MSTAN
       288        0       10       -0      -0      -0       -0      -0      -0      -0
                                 JOPER      NHT   LROPT   TRACE
                                     5       -0      -0      -0

                        MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1 NRTIO= 4 LRTIO= 1
                  RTIOS=     .25     .50     .75    1.00

                                SUB-AREA RUNOFF COMPUTATION

     PINE TREE LAKES PMF RATIO INFLOW HYDROGRAPHS.

                    ISTAO   ICOMP   IECON   ITAPE   JPLT   JPRT  INAME  ISTAGE  IAUTO
                    0-IN        0      -0      -0     -0     -0      1      -0     -0

                                HYDROGRAPH DATA
      IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO   ISNOW   ISAME   LOCAL
          1        2      .15       -0.      .15     1.00       -0.      -0       1      -0

                                  PRECIP DATA
                SPFE      PMS       R6      R12      R24      R48      R72      R96
                0.      26.00   102.00   120.00   130.00   140.00     -0.      -0.

                                  LOSS DATA
      LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         -0      -0.     -0.    1.00      -0.     -0.    1.00   -1.00  -89.00      -0.     .05

      CURVE NO =  -89.00  WETNESS =   -1.00  EFFECT CN =   89.00

                              UNIT HYDROGRAPH DATA
                          TC= -0.      LAG=   .71

                                RECESSION DATA
                      STRTQ=   -2.00    QRCSN=    -.05    RTIOR= 5.00

     UNIT HYDROGRAPH 23 END OF PERIOD ORDINATES, TC=   -0.   HOURS, LAG=    .71  VOL= 1.00
```

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

LOSS DATA

LKRTP	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-89.00	-0.	.05

CURVE NO = -89.00 RETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA

TC= -0. LAG= .71

RECESSION DATA

STRTQ= -2.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 23 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .71 VOL= 1.00

10.	31.	65.	88.	92.	82.	66.	45.	31.	23.
16.	12.	8.	6.	4.	3.	2.	1.	1.	1.
1.	0.	0.							

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	0.	1.02	.10	145	.03	.03	.00	2.
1.01	.20	2	.00	.00	.00	0.	1.02	.20	146	.03	.03	.00	3.
1.01	.30	3	.00	.00	.00	0.	1.02	.30	147	.03	.03	.00	4.
1.01	.40	4	.00	.00	.00	0.	1.02	.40	148	.03	.03	.00	6.
1.01	.50	5	.00	.00	.00	0.	1.02	.50	149	.03	.03	.00	8.
1.01	1.00	6	.00	.00	.00	0.	1.02	1.00	150	.03	.03	.00	10.
1.01	1.10	7	.00	.00	.00	0.	1.02	1.10	151	.03	.03	.00	12.
1.01	1.20	8	.00	.00	.00	0.	1.02	1.20	152	.03	.03	.00	13.
1.01	1.30	9	.00	.00	.00	0.	1.02	1.30	153	.03	.03	.00	13.
1.01	1.40	10	.00	.00	.00	0.	1.02	1.40	154	.03	.03	.00	14.
1.01	1.50	11	.00	.00	.00	0.	1.02	1.50	155	.03	.03	.00	14.
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1.01	2.20	14	.00	.00	.00	0.	1.02	2.20	158	.03	.03	.00	15.
1.01	2.30	15	.00	.00	.00	0.	1.02	2.30	159	.03	.03	.00	15.
1.01	2.40	16	.00	.00	.00	0.	1.02	2.40	160	.03	.03	.00	15.
1.01	2.50	17	.00	.00	.00	0.	1.02	2.50	161	.03	.03	.00	15.
1.01	3.00	18	.00	.00	.00	0.	1.02	3.00	162	.03	.03	.00	15.
1.01	3.10	19	.00	.00	.00	0.	1.02	3.10	163	.03	.03	.00	15.
1.01	3.20	20	.00	.00	.00	0.	1.02	3.20	164	.03	.03	.00	15.
1.01	3.30	21	.00	.00	.00	0.	1.02	3.30	165	.03	.03	.00	15.
1.01	3.40	22	.00	.00	.00	0.	1.02	3.40	166	.03	.03	.00	15.
1.01	3.50	23	.00	.00	.00	0.	1.02	3.50	167	.03	.03	.00	16.
1.01	4.00	24	.00	.00	.00	0.	1.02	4.00	168	.03	.03	.00	16.
1.01	4.10	25	.00	.00	.00	0.	1.02	4.10	169	.03	.03	.00	16.
1.01	4.20	26	.00	.00	.00	0.	1.02	4.20	170	.03	.03	.00	16.
1.01	4.30	27	.00	.00	.00	0.	1.02	4.30	171	.03	.03	.00	16.
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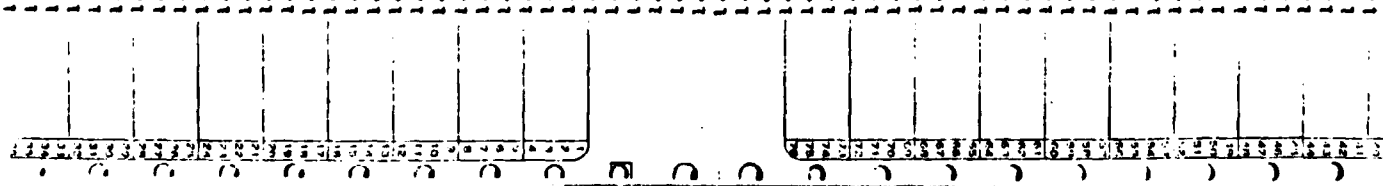
1.01	4.50	29	.00	.00	.00	0.	1.02	4.50	173	.03	.03	.00	16.
1.01	5.00	30	.00	.00	.00	0.	1.02	5.00	174	.03	.03	.00	16.
1.01	5.10	31	.00	.00	.00	0.	1.02	5.10	175	.03	.03	.00	16.
1.01	5.20	32	.00	.00	.00	0.	1.02	5.20	176	.03	.03	.00	16.
1.01	5.30	33	.00	.00	.00	0.	1.02	5.30	177	.03	.03	.00	16.
1.01	5.40	34	.00	.00	.00	0.	1.02	5.40	178	.03	.03	.00	16.
1.01	5.50	35	.00	.00	.00	0.	1.02	5.50	179	.03	.03	.00	16.
1.01	6.00	36	.00	.00	.00	0.	1.02	6.00	180	.03	.03	.00	16.
1.01	6.10	37	.01	.00	.01	0.	1.02	6.10	181	.13	.12	.01	17.
1.01	6.20	38	.01	.00	.01	0.	1.02	6.20	182	.13	.12	.01	20.
1.01	6.30	39	.01	.00	.01	0.	1.02	6.30	183	.13	.12	.01	26.
1.01	6.40	40	.01	.00	.01	0.	1.02	6.40	184	.13	.12	.01	34.

Output Summary
Various PMF Events
Pine Tree Lake East Dam
MO ID No 30992
B6

Output Summary
Various PMF Events
Pine Tree Lake East Dam
MO ID No 30992
B7



Output Summary
Various PMF Events
Pine Tree Lake East Dam
MO ID No 30992
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1.01	14.40	88	.05	.03	.02	14.	1.02	14.40	232	.66	.66	.00	328.
1.01	14.50	89	.05	.03	.02	15.	1.02	14.50	233	.66	.66	.00	343.
1.01	15.00	90	.05	.04	.02	17.	1.02	15.00	234	.66	.66	.00	355.
1.01	15.10	91	.05	.03	.01	17.	1.02	15.10	235	.60	.60	.00	369.
1.01	15.20	92	.08	.06	.02	18.	1.02	15.20	236	1.01	1.00	.00	374.
1.01	15.30	93	.14	.10	.04	20.	1.02	15.30	237	1.81	1.81	.01	395.
1.01	15.40	94	.35	.27	.07	25.	1.02	15.40	238	4.53	4.52	.01	472.
1.01	15.50	95	.10	.08	.02	34.	1.02	15.50	239	1.31	1.31	.00	610.
1.01	16.00	96	.06	.05	.01	45.	1.02	16.00	240	.81	.80	.00	785.
1.01	16.10	97	.05	.04	.01	53.	1.02	16.10	241	.62	.62	.00	901.
1.01	16.20	98	.05	.04	.01	55.	1.02	16.20	242	.62	.62	.00	920.
1.01	16.30	99	.05	.04	.01	52.	1.02	16.30	243	.62	.62	.00	861.
1.01	16.40	100	.05	.04	.01	46.	1.02	16.40	244	.62	.62	.00	761.
1.01	16.50	101	.05	.04	.01	40.	1.02	16.50	245	.62	.62	.00	646.
1.01	17.00	102	.05	.04	.01	35.	1.02	17.00	246	.62	.62	.00	563.
1.01	17.10	103	.04	.03	.01	32.	1.02	17.10	247	.49	.49	.00	505.
1.01	17.20	104	.04	.03	.00	29.	1.02	17.20	248	.49	.49	.00	460.
1.01	17.30	105	.04	.03	.00	27.	1.02	17.30	249	.49	.49	.00	422.
1.01	17.40	106	.04	.03	.00	25.	1.02	17.40	250	.49	.49	.00	389.
1.01	17.50	107	.04	.03	.00	24.	1.02	17.50	251	.49	.49	.00	362.
1.01	18.00	108	.04	.03	.00	22.	1.02	18.00	252	.49	.49	.00	341.
1.01	18.10	109	.00	.00	.00	21.	1.02	18.10	253	.04	.04	.00	320.
1.01	18.20	110	.00	.00	.00	20.	1.02	18.20	254	.04	.04	.00	295.
1.01	18.30	111	.00	.00	.00	17.	1.02	18.30	255	.04	.04	.00	259.
1.01	18.40	112	.00	.00	.00	14.	1.02	18.40	256	.04	.04	.00	214.
1.01	18.50	113	.00	.00	.00	11.	1.02	18.50	257	.04	.04	.00	169.
1.01	19.00	114	.00	.00	.00	9.	1.02	19.00	258	.04	.04	.00	130.
1.01	19.10	115	.00	.00	.00	7.	1.02	19.10	259	.04	.04	.00	98.
1.01	19.20	116	.00	.00	.00	5.	1.02	19.20	260	.04	.04	.00	77.
1.01	19.30	117	.00	.00	.00	4.	1.02	19.30	261	.04	.04	.00	61.
1.01	19.40	118	.00	.00	.00	3.	1.02	19.40	262	.04	.04	.00	51.
1.01	19.50	119	.00	.00	.00	3.	1.02	19.50	263	.04	.04	.00	44.
1.01	20.00	120	.00	.00	.00	3.	1.02	20.00	264	.04	.04	.00	38.
1.01	20.10	121	.00	.00	.00	2.	1.02	20.10	265	.04	.04	.00	34.
1.01	20.20	122	.00	.00	.00	2.	1.02	20.20	266	.04	.04	.00	32.
1.01	20.30	123	.00	.00	.00	2.	1.02	20.30	267	.04	.04	.00	30.
1.01	20.40	124	.00	.00	.00	2.	1.02	20.40	268	.04	.04	.00	28.
1.01	20.50	125	.00	.00	.00	2.	1.02	20.50	269	.04	.04	.00	27.
1.01	21.00	126	.00	.00	.00	2.	1.02	21.00	270	.04	.04	.00	27.
1.01	21.10	127	.00	.00	.00	2.	1.02	21.10	271	.04	.04	.00	26.
1.01	21.20	128	.00	.00	.00	2.	1.02	21.20	272	.04	.04	.00	26.
1.01	21.30	129	.00	.00	.00	2.	1.02	21.30	273	.04	.04	.00	26.
1.01	21.40	130	.00	.00	.00	2.	1.02	21.40	274	.04	.04	.00	26.
1.01	21.50	131	.00	.00	.00	2.	1.02	21.50	275	.04	.04	.00	25.
1.01	22.00	132	.00	.00	.00	2.	1.02	22.00	276	.04	.04	.00	25.
1.01	22.10	133	.00	.00	.00	2.	1.02	22.10	277	.04	.04	.00	25.
1.01	22.20	134	.00	.00	.00	2.	1.02	22.20	278	.04	.04	.00	25.
1.01	22.30	135	.00	.00	.00	2.	1.02	22.30	279	.04	.04	.00	25.
1.01	22.40	136	.00	.00	.00	2.	1.02	22.40	280	.04	.04	.00	25.
1.01	22.50	137	.00	.00	.00	2.	1.02	22.50	281	.04	.04	.00	25.
1.01	23.00	138	.00	.00	.00	2.	1.02	23.00	282	.04	.04	.00	25.
1.01	23.10	139	.00	.00	.00	2.	1.02	23.10	283	.04	.04	.00	25.
1.01	23.20	140	.00	.00	.00	2.	1.02	23.20	284	.04	.04	.00	25.
1.01	23.30	141	.00	.00	.00	2.	1.02	23.30	285	.04	.04	.00	25.
1.01	23.40	142	.00	.00	.00	2.	1.02	23.40	286	.04	.04	.00	25.
1.01	23.50	143	.00	.00	.00	2.	1.02	23.50	287	.04	.04	.00	25.
1.02	0.	144	.00	.00	.00	2.	1.03	0.	288	.04	.04	.00	25.
									SUM	36.40	35.03	1.37	20467.
										925.11	890.11	35.11	579.56

	PEAK	5-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	920.	417.	136.	71.	20464.
CMS	26.	12.	4.	2.	579.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	0-IN	.15	1	230.	460.	690.	920.
		(.391)		(6.51)	(13.03)	(19.54)	(26.05)
ROUTED TO	DAM	.15	1	212.	457.	690.	921.
		(.391)		(5.99)	(12.93)	(19.53)	(26.09)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	994.00	994.00	996.00
STORAGE	52.	52.	63.
OUTFLOW	0.	0.	121.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	996.33	.33	65.	212.	1.50	40.50	0.
.50	996.68	.68	67.	457.	4.67	40.33	0.
.75	996.87	.87	68.	690.	5.83	40.33	0.
1.00	997.03	1.03	69.	921.	6.50	40.33	0.

Output Summary
Various PMF Events
Pine Tree Lake East Dam
MO ID No 30992
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4
				.15	.16	.17	.19
HYDROGRAPH AT	0-IN	.15	1	138.	147.	156.	166.
		(.39)	(	3.91)(	4.17)(	4.43)(	4.69)(
ROUTED TO	DAM	.15	1	101.	110.	120.	130.
		(.39)	(	2.87)(	3.13)(	3.40)(	3.69)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	994.00	994.00	996.00
STORAGE	52.	52.	63.
OUTFLOW	0.	0.	121.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.15	995.86	0.	62.	101.	0.	40.83	0.
.16	995.93	0.	63.	110.	0.	40.83	0.
.17	996.00	0.	63.	120.	0.	40.67	0.
.18	996.06	.06	63.	130.	.67	40.67	0.

Output Summary
Equivalent PMF Analyses
Pine Tree Lake East Dam
MO ID No 30992
B10

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-PD

SUBJECT: Pine Tree Lake West Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Pine Tree Lake East Dam MO 30992 and Pine Tree Lake West Dam MO 30995, Washington County, Missouri.

It was prepared under the National Program of Inspection of Non-Federal Dams.

These dams have been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

a. The common spillway for MO 30992 and 30995 will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

b. Overtopping could result in dam failure.

c. Dam failure significantly increases the hazard to life and property downstream.

Pine Tree Lake West Dam will be overtopped by a 10-year frequency flood. Pine Tree Lake East Dam will not be overtopped primarily as a consequence of overtopping of Pine Tree Lake West Dam, and as these dams share a common spillway, this spillway is judged unusually small and seriously inadequate for both dams.

Submitted by: _____ _____
Chief, Engineering Division Date

Approved by: _____ _____
Colonel, CE, District Engineer Date

PINE TREE LAKE WEST DAM

Washington County, Missouri

Missouri Inventory No. 30995

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

September 1980

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Pine Tree Lake West Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of North Fork, Fourche a Renault
Date of Inspection	23 June 1980

Pine Tree Lake West Dam, Missouri Inventory No. 30995, was inspected by L. M. Krazynski (geotechnical engineer), R. Juyal (hydrologist) and J. B. Stevens (geotechnical engineer). The dam is an earth dam used for recreational purposes.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious indentification based on available data and a visual inspection of those dams which might pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers (SLD) has classified this dam high hazard potential; we concur with this classification. The estimated hazard zone extends approximately two miles below the dam. There are several occupied residences and Missouri Hwy 8 located within 0.5 mi downstream of the dam. Loss of life and property damage could be significant in the event of failure.

The dam is classified as a small size dam due to its 28 ft height, and its storage capacity of 59 ac-ft. Dams within the small size classification have heights between 25 and 40 ft or storage capacities between 50 and 1000 ac-ft.

Our inspection and evaluation indicate the dam is in generally poor condition. The principal reason for this judgment is the small spillway capacity. No evidence of instability of the embankment was observed at the time inspection. The slopes and crest of the dam have a thick grass cover with scattered brush and small trees, except in the roadway. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for the Safety Inspection of Dams" were not available.

Hydrologic/hydraulic studies indicate that a 10 percent probability-of-occurrence event (10-yr flood) will result in overtopping of the dam. The 10 percent probability-of-occurrence event will not overtop the Pine Tree Lake East Dam. The two dams share a common spillway and the east dam crest for overtopping analyses is 0.7 ft higher than the west embankment. These analyses also indicate that the dam will be overtopped for a hydrologic event which produces greater than nine percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

It is recommended that the following remedial measures and additional studies be undertaken for the Pine Tree Lake West Dam:

1. Design and construction of a spillway system with the capacity to pass 100 percent of the PMF. The PMF is the recommended spillway design flood, due to the number and proximity of the downstream residences. Potential failure of this dam is judged to represent a significant hazard for loss of life and property. The design of the new spillway system should also consider the location, size and erodibility of the downstream discharge channel. Potential for significant erosion at the toe of the dam should be minimized. Consideration should also be given to the removal (or re-design) of the existing wooden bridge crossing the existing spillway, to avoid the risk of obstructing the spillway or the discharge channel during flood flows.

   It may be possible to design the new spillway system for a design flood of less than 100 percent of the PMF, if it can be demonstrated by the more detailed hydraulic/hydrologic study that with minimal potential overtopping of small depth and duration the hazard to the downstream residents and property can be minimized to an acceptable level.

2. Repair, if needed, of the leak in the low level discharge pipe at the toe of the dam.

3. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed for appropriate loading conditions (including seismic) and made a matter of record.

4. Evaluation of available options for an effective and practical warning system is recommended, to alert downstream residents should potentially hazardous conditions develop.

A program of periodic inspections and maintenance should be implemented for the dam and appurtenant structures. This program should include but not be limited to the following:

1. Inspection of the embankment to identify any signs of slope instability such as slumping or cracking, and/or possible future development of seepage through the dam embankment.

2. Periodic inspection of slope vegetation to determine the need for removal of detrimental trees and brush. Large tree removal should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing could jeopardize the safety of the dam.

3. Inspection of the outlet pipe for evidence of leakage or piping adjacent to the pipe.

4. Inspection of the discharge channel for evidence of serious erosion from continued outflow.

All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Records of recommended and performed maintenance on the facilities should be kept.

It is recommended that the owner take action on the recommendations concerning the design and construction of an adequate spillway system. Action on other recommendations should be taken without undue delay.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

Leonard M. Krazynski, P.E.
Vice President

OVERVIEW

PINE TREE LAKE WEST DAM

MISSOURI INVENTORY NUMBER 30995

Pine Tree Lake West Dam on left side of photo; Pine Tree Lake East Dam on right side of photo.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
PINE TREE LAKE WEST DAM, MISSOURI INVENTORY NO. 30995
TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
PINE TREE LAKE WEST DAM, MISSOURI INVENTORY No. 30995

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Pine Tree Lake West Dam, Missouri Inventory Number 30995.

b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations, and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams" prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Pine Tree Lake West Dam is an earth dam constructed to form a recreational lake. An uncontrolled, concrete-lined spillway is located at the east end of the dam. This spillway also serves Pine Tree Lake East Dam (MO 30992). There is a low-level outlet pipe at the toe of the Pine Tree Lake West Dam. The outlet consists of a 4-in. diameter clay pipe and is controlled by a hand-operated valve near the exit point.

b. **Location.** The dam is located 5.3 mi WSW of Potosi, Washington CO, Missouri in Sec 24, T37N, R1E, immediately north of Missouri Highway 8, on the USGS Potosi 7.5-minute quadrangle map. The dam is on an unnamed tributary of the North Fork of the Fourche a Renault.

c. **Size classification.** The dam is classified as a small size dam due to its 28 ft height and its storage volume of 59 ac-ft. The classification for a small size dam is based on a height between 25 and 40 ft or a storage capacity between 50 and 1000 ac-ft.

d. **Hazard classification.** The SLD has classified this dam high hazard potential; we concur with this classification. The estimated hazard zone extends approximately two miles below the dam. There are several occupied residences and Missouri Hwy 8 located within 0.5 mi downstream of the dam. Loss of life and property damage could be significant in the event of failure.

e. **Ownership.** We understand the dam is owned by A.M. Enterprises, 10 Meadowbrook Country Club Est., Ballwin, Missouri 63011. Correspondence should be addressed to the attention of Mr Eugene Alper.

f. **Purpose of dam.** The impoundment is used for recreational purposes.

g. **Design and construction history.** According to Mr Eugene Alper, the dam was constructed in 1975. There was no specific design for the dam but guidelines for small dams published by the Missouri Conservation Commission were reportedly followed. Soil for the dam was obtained from the present lake area and placed with a dozer and scraper. The fill was compacted only with this equipment; rollers were not used. It is our understanding that the spillway was not designed by an engineer.

h. **Normal operating procedures.** No operating records were found. Flood flows pass over the uncontrolled spillway at the east end of the dam. No minimum or maximum operating pool elevations are apparently maintained.

1.3 Pertinent Data

a. **Drainage area.** Approximately 0.15 mi^2 (This includes the area contributing to Pine Tree Lake East Dam (Missouri 30992) because the two reservoirs are connected and share one spillway).

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	52 ft^3/sec (at el 995.3)
Total spillway capacity at maximum pool elevation	52 ft^3/sec (at el 995.3)

c. **Elevation (ft above MSL).**

Top of dam	995.3 to 998.4
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	994.0
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	969.5

d. **Reservoir.**

Length of maximum pool	700 ft
Length of recreation pool	700 ft
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	52
Flood control pool	N/A
Design surcharge	N/A
Top of dam	59

f. **Reservoir surface (acres).**

Top of dam	6
Maximum pool	6
Flood-control pool	N/A
Recreation pool	5.5
Spillway crest	5.5

g. **Dam.**

Type	Earth fill
Length	581 ft
Height	28 ft
Top width	18 ft
Side slopes	Downstream 2(H) to 1(V); Upstream unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably homogeneous section of gravelly clay (CH))
Cutoff	Reported by owner to be 35 ft wide 8 ft deep trench to bedrock backfilled with relatively rock-free clay
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating Facilities	N/A

i. **Spillway.**

Type	Trapezoidal, broad-crested concrete weir
Length of weir	18 ft (top), 6 ft (bottom)
Crest elevation	994 ft
Gates	None
Upstream channel	None
Downstream channel	Earth; typically 8 ft wide, 4 ft deep

j. **Regulating outlets.** 4-in. diameter clay pipe with valve at downstream end. No record of operation.

SECTION 2
ENGINEERING DATA

2.1 Design

No design plans or reports were found for Pine Tree Lake West Dam.

2.2 Construction

No construction records or data were found.

2.3 Operation

No records were found for maintaining a maximum or minimum operating pool elevation. No records were found documenting the operation of the valve and drain at the toe of the dam nor was it reliably determined that the drain is in fact a functioning low level outlet for the lake.

There are no records of outflow at the spillway or of the history of the pool elevations.

2.4 Evaluation

a. **Availability.** The only engineering data obtained for this report was developed during the field inspection. No engineering design data or construction reports were found for this dam.

b. **Adequacy.** Insufficient data were available to determine the adequacy of the design.

Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be conducted by a engineer experienced in the design and construction of dams.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site is located on the northern flank of the Ozark structural dome. The bedrock in the area is mapped as Ordovician age Gasconade Formation on the Geologic Map of Missouri (Fig 4). The Gasconade Formation is predominantly a cherty dolomite which varies from coarsely crystalline and very cherty at the top to finely crystalline with relatively small amounts of chert near the bottom of the formation. Caves and springs are common in this formation in the central Ozarks, but the field inspection did not identify any evidence of solution activity in the vicinity of the dam.

The soil at the dam site is a gravelly plastic residual clay (CH) developed on the Gasconade Formation. The site area is mapped on the Missouri General Soils Map as Captina-Clarksville-Doniphan Association.

Three faults or fault zones are mapped within 5 mi of the dam (Fig 4). The Shirley Fault Zone is mapped as approximately 8 mi in length, terminating less than 0.5 mi west of the dam. This fault is mapped as northeast side up. The Palmer Fault Zone, a complex network of short and long faults approximately 34 mi long is located approximately 5 mi south of the dam. The fault is mapped as down to the north. The Aptus Fault is located approximately 4 mi northeast of the dam. This fault has a mapped length of approximately 15 mi and is mapped as up to the northwest.

All of the faults in the vicinity of the dam are within Palezoic age formations. There was no evidence of recent activity found and the area is not considered seismically active. The faults are likely Paleozoic in age and are not considered to pose an unusually high seismic hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was made of Pine Tree Lake West Dam on 23 June 1980 without an owner's representative present.

b. **Dam.** The dam was constructed with a gravelly, dark red, plastic clay (CH) obtained from the reservoir area. The gravel is an angular chert ranging in size from coarse sand to cobbles.

The slopes and crest of the dam have a thick grass cover with scattered small bushes and young trees, except in the roadway. There is no riprap on the upstream slope and it is bare of vegetation to about the spillway elevation, which coincides closely with the discernable high-water mark. The upstream face erosion potential is judged to be low because of a short fetch available to develop waves in the impoundment.

The vertical and horizontal alignment of the dam appear undisturbed. There is no evidence of sinkhole development, detrimental settlement, slides, depressions, cracking or animal burrows. No evidence of previous overtopping was observed.

No seepage through the earth embankment was observed at the time of our inspection.

c. **Appurtenant structures.**

1. Spillway. The spillway is a trapezoidal concrete weir, approximately 6 ft wide at the bottom, 18 ft wide at the top and having a height of about 1 ft to the top of concrete. A wooden bridge carries the road across the spillway but is not anchored to the dam in any way (Photo 4). The measured elevation at the bottom of the wooden bridge girders is 994.9 ft and the average elevation

at the spillway crest is 994.1 ft. There is only about 0.8 ft average clearance between the bottom of the bridge girders and the concrete spillway channel; hence, flows will be severely restricted. In the event of high water, the bridge may be moved downstream and there is a risk that it may become a significant obstruction to the flow of water in the spillway discharge channel. It may also divert the flow and cause severe erosion of the embankment. A concrete apron extends about 25 ft downstream from the spillway entrance. At the entrance is an open construction joint. Near the downstream end of the apron, there is a 5-in. high concrete wall with the apparent intended purpose of energy dissipation (Photo 4). Since there were no plans or records of construction available for review it is not known whether the concrete lining is adequately reinforced or whether a waterstop was provided for prevention of entry of water under the lining. Therefore, it is not known whether the spillway concrete lining will perform adequately from a structural standpoint during periods of heavy flow.

2. Low level outlet. The low level outlet observed at the toe of the dam consists of 4-in. diameter clay pipe controlled by a protected valve located at the downstream end. The valve has apparently not been maintained and it was not operated by the inspection team for fear of possible breakage. Generally it is more desirable to locate the valve on the upstream end of the pipe so that the pipe does not always contain water under pressure. It was not reliably determined that this pipe and valve are a functioning low level outlet. Clear flow of about 3 gal/min was coming from pipe. The flow was ponded in an approximately 100 x 100 ft area near the toe of the dam.

d. **Reservoir area.** The reservoir is used for recreational purposes. There are several vacation homes on the slopes surrounding the reservoir. These slopes are heavily wooded and generally flatter than 4(H) to 1(V), and showed no signs of instability at the time of our field inspection.

As the drainage area is heavily wooded, there apparently has been very little sediment transported into the lake.

e. **Downstream channel.** The downstream discharge channel (Photo 5) is typically 8 ft wide and 4 ft deep. It is cut into the natural ground and is not protected against erosion. The soil is considered to be moderately erodible. Some bushes were growing in the channel.

3.2 Evaluation

Our visual inspection indicated the dam is in generally poor condition. This judgment is based primarily on the small spillway capacity and the potential for obstructions in the spillway and discharge channel.

The spillway lining may not perform adequately during high flows. The bridge in the spillway may become an obstruction in the downstream channel and cause diversion of the flow and erosion of the embankment.

Our visual inspection did not find any sinkhole development, detrimental settlement, depressions, slides, cracking or other evidence of instability of the dam embankment. Animal burrows also were not present. No evidence of previous overtopping was observed.

No seepage was noted from the embankment. At its present volume, the seepage from the low level outlet does not appear to endanger the safety of the dam. The lack of maintenance of the valve and drain however may cause problems in the future.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level is controlled by the crest of the small ungated concrete spillway.

4.2 Maintenance of Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

The clay pipe and valve, assumed to be a low level outlet from the lake, were not verified as being in an operative condition at the time of the inspection. However, a small, clear flow was exiting from the pipe at the time of inspection indicating the valve was partly open or leaking. No records were available on maintenance or operation of this outlet.

4.4 Description of any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There are apparently no maintenance or operational procedures in effect. The lack of regular maintenance and periodic inspection is considered a deficiency.

The feasibility of a practical and effective warning system should be evaluated to alert downstream residents, should potentialiy hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic information was available for evaluation of the dam. Pertinent dimensions of the dam and reservoir were surveyed on 19 June 1980, measured during the field inspection or estimated from topographic mapping. The maps used in the analyses were the USGS Shirley and Potosi 7.5-minute quadrangle maps.

b. **Experience data.** No recorded history of rainfall, runoff, discharge or pool stage data were available for this reservoir or watershed.

c. **Visual observations.** At the time of inspection, the spillway was crossed by a wooden bridge which derives it support from the spillway sides. The bridge is not anchored and is apparently intended to be removed by the water in the event of high spillway flow. In those circumstances the dislocated bridge may create an obstruction in the discharge channel. No other conditions were noted which could lead to a reduced spillway capacity during a flood occurrence. Other observations regarding the reservoir, spillway and discharge channel are given in Section 3.

d. **Overtopping potential.** Pine Tree Lake West Dam shares a common spillway and drainage basin with Pine Tree Lake East Dam (MO 30992). The reservoirs of the two dams are connected by a canal of undetermined depth. The canal crosses a natural ridge that partially separates the two reservoirs. The spillway is located on the south bank of this canal.

For overtopping analyses, the elevation of the top of the west dam was taken as 995.3 ft, a point on the crest of the earth dam adjacent the concrete-lined spillway. Flows above this elevation would overtop the crest dam. When the reservoir surface elevation rises above 996.0 ft, the east dam is also overtopped.

Hydraulic/hydrologic analyses indicate that the Pine Tree Lake West Dam will be overtopped by the 10 percent probability-of-occurrence event. These analyses also indicate that a storm that produces greater than nine percent of the Probable Maximum Flood (PMF) will cause overtopping of the embankment. The PMF is defined as the flood event that may be expected occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The following table presents the expected severity of overtopping for various precipitation events:

Percent PMF	Maximum W.S. Elev., ft, MSL	Max. Depth Over Dam, ft	Max. Outflow, ft^3/sec	Duration of Overtopping, hrs
9	995.3	0.0	52	0
50	996.7	1.4	460	7.0
100	997.0	1.7	920	12.3

The depth and duration of overtopping of this dam will be likely to cause significant erosion on the dam crest, downstream dam face and downstream discharge channel. If significant erosion is allowed along the toe of the dam in the discharge channel, the channel will be widened and deepened. This widening and deepening of the channel will probably undermine a portion of the toe of the dam and may result in a dam failure. Due to the proximity of the downstream residences, the recommended spillway design flood is 100 percent of the PMF. More detailed studies such as erosion potential studies of the embankment soils and discharge channel, and inundation studies of the downstream channel may justify designing the spillway system to a design storm less than the PMF. These studies are beyond the scope of this Phase I report.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** The visual inspection of the Pine Tree Lake West Dam revealed no evidence of horizontal or vertical displacement of the dam crest alignment. Cracking, detrimental settlement, slides, depressions or other signs of instability were not observed. No seepage through the embankment on the downstream slope or at the toe was observed, except for the small leak from the clay outlet pipe. Vegetation on the crest and slopes (except for the roadway) consists of thick grasses and with few small bushes. The vegetation does not appear to represent a hazard to the safety of the dam at this time.

The soil used to construct the dam is not considered as having a high liquefaction potential. The erodibility of the soils on the downstream slope are judged to be low due to the thick grass cover. This grass cover may be partially removed causing the dam to have a higher erosion potential, if subjected to flow velocities greater than 5 ft/sec.

b. **Design and construction data.** No design or construction data were available for this dam and spillway. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available.

c. **Operating records.** No operating records or water level records are maintained for this facility.

d. **Post construction changes.** The lack of drawings or construction reports precludes the identification of post construction changes. However, there were no obvious changes observed.

e. **Seismic stability.** The dam is Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction is unlikely during a moderate seismic event. However, since no static stability analysis is available for review, the seismic stability cannot be properly evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, the Pine Tree Lake West Dam appears to be in generally poor condition. The low spillway capacity is the primary reason for this judgment. The spillway is unable to pass the 10 percent probability-of-occurrence event without overtopping the dam. The spillway will pass only nine percent of the PMF without overtopping the dam. If Pine Tree Lake West Dam were to fail, a portion of the storage of Pine Tree Lake East would be released, as the two reservoirs are only partially separated by a ridge. Based on our visual inspection the dam earth embankment itself is judged to be in a generally good condition, but seepage and stability analyses comparable to the requirements of the recommended guidelines, were not available.

b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations in this Phase I report.

Seepage and stability analyss comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. This is considered a deficiency.

c. **Urgency.** The deficiencies described in this report could affect the risk of failure of this dam. It is suggested the recommendations concerning the design and construction of an adequate spillway system be implemented immediately to prevent possible overtopping of the dam. Action on other recommendations should be taken without undue delay.

d. **Necessity for Phase II.** In accordance with the Recommended Guidelines for Safety Inspection of Dams, the subject investigation was a minimum study. This study revealed that additional in-depth investigations and remedial measures as described in Section 7.2 are needed to improve the safety of the dam. It is our understanding from discussions with the St Louis District that these additional in-depth investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent the storage of water.

2. Increase the height of dam and/or spillway size to pass the probable maximum flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Enhance the stability of the dam to permit overtopping by the probable maximum flood without failure.

5. Provide a highly reliable flood warning system (generally does not prevent damage but decreases the chances for loss of life).

b. **Recommendations.** Based on our inspection of the facilities at Pine Tree Lake West Dam, it is recommended that further studies be conducted immediately to evaluate, as a minimum, the following topics:

1. Design and construction of a spillway system with the capacity to pass 100 percent of the PMF. The PMF is the recommended spillway design flood, due to the number and proximity of the downstream residences. Potential failure of this dam is judged to represent a significant hazard for loss of life and property. The design of the new spillway system should also consider the location, size and erodibility of the downstream discharge channel. Potential for significant erosion at the toe of the dam should be minimized. Consideration should also be given to the removal (or re-design) of the existing wooden bridge crossing the existing spillway, to avoid the risk of obstructing the spillway or the discharge channel during flood flows.

It may be possible to design the new spillway system for a design flood of less than 100 percent of the PMF, if it can be demonstrated by the more detailed hydraulic/hydrologic study that with minimal potential overtopping of small depth and duration the hazard to the downstream residents and property can be minimized to an acceptable level.

Additional topics, which should be addressed without undue delay, include the following:

2. Repair, if needed, of the leak in the low level discharge pipe at the toe of the dam.

3. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of the Dams", should be performed for appropriate loading conditions (including seismic) and made a matter of record.

4. Evaluation of available options for an effective and practical warning system is recommended, to alert downstream residents should potentially hazardous conditions develop at the dam.

The recommended analyses and remedial measures should be done under the guidance of an engineer experienced in the design and construction of earth dams.

c. **O & M procedures.** A program of periodic inspections and maintenance should be implemented for the dam and appurtenant structures. This program should include, but not be limited to, the following:

1. Inspection of the embankment to identify any signs of slope instability such as slumping or cracking, and/or possible future development of seepage through the dam embankment.

2. Slope and crest vegetation should be inspected periodically to identify detrimental effects to the dam and spillway. Removal of large trees should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing could jeopardize the safety of the dam.

3. Inspection of the clay outlet pipe for evidence of leakage or piping adjacent to the pipe;

4. Inspection of the discharge channel for evidence of serious erosion from continued outflow.

The result of the inspections should be to identify and recommend necessary maintenance. Records of inspections and recommended and performed maintenance on the facilities should be kept. All inspections and maintenance should be done under the guidance of an engineer experienced in the design and construction of dams.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, "National Program of Inspection of Non-Federal Dams".

Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, "National Program of Inspection of Non-Federal Dams".

Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

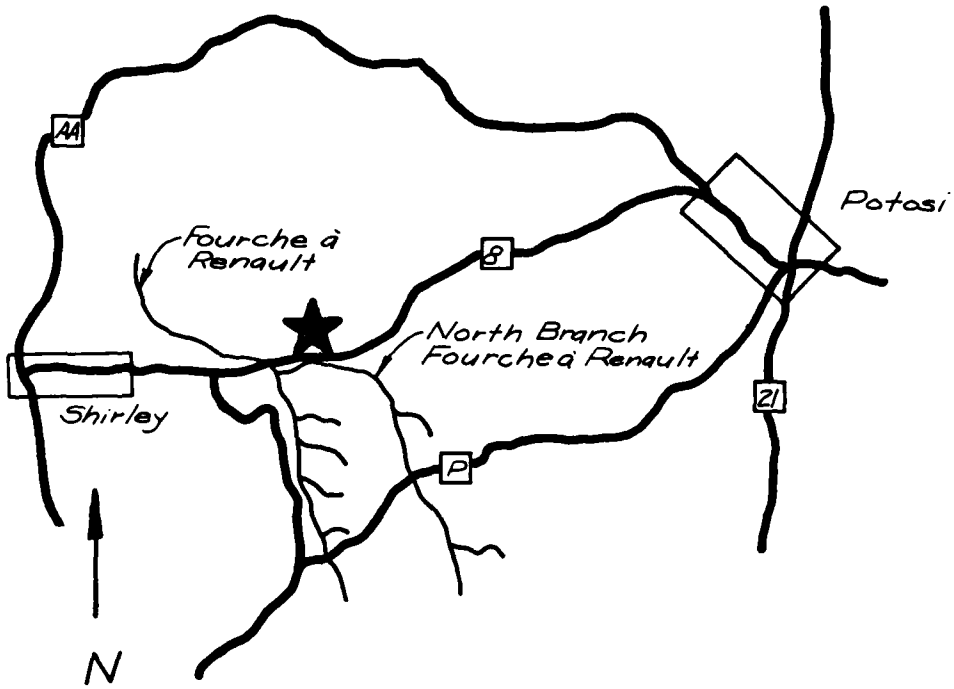
Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.

Vicinity Map



N

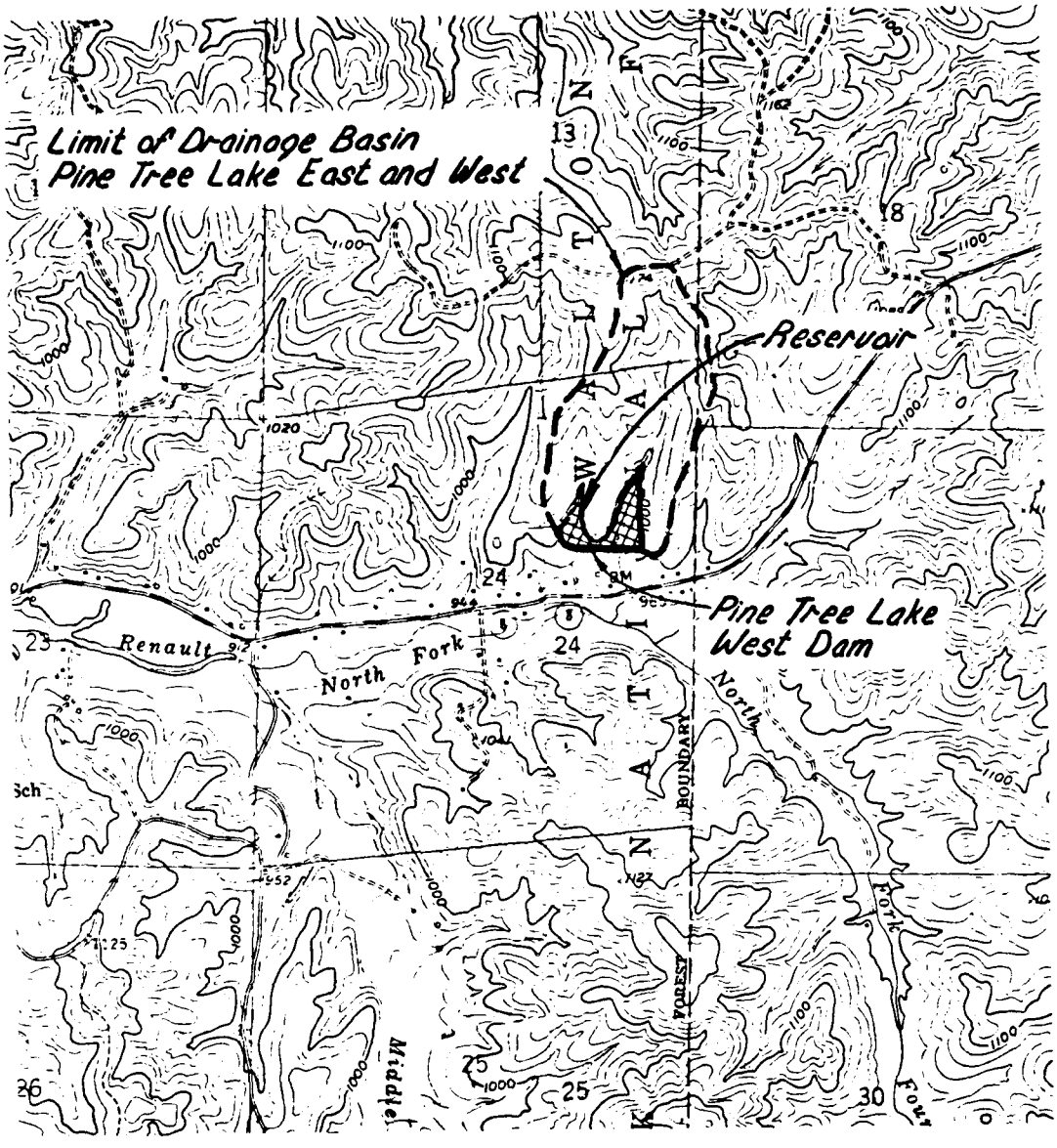
0 2 4

Scale, miles

Legend

- County Line
- State highway and Route No.
- River or Creek
- City or Town
- Project location

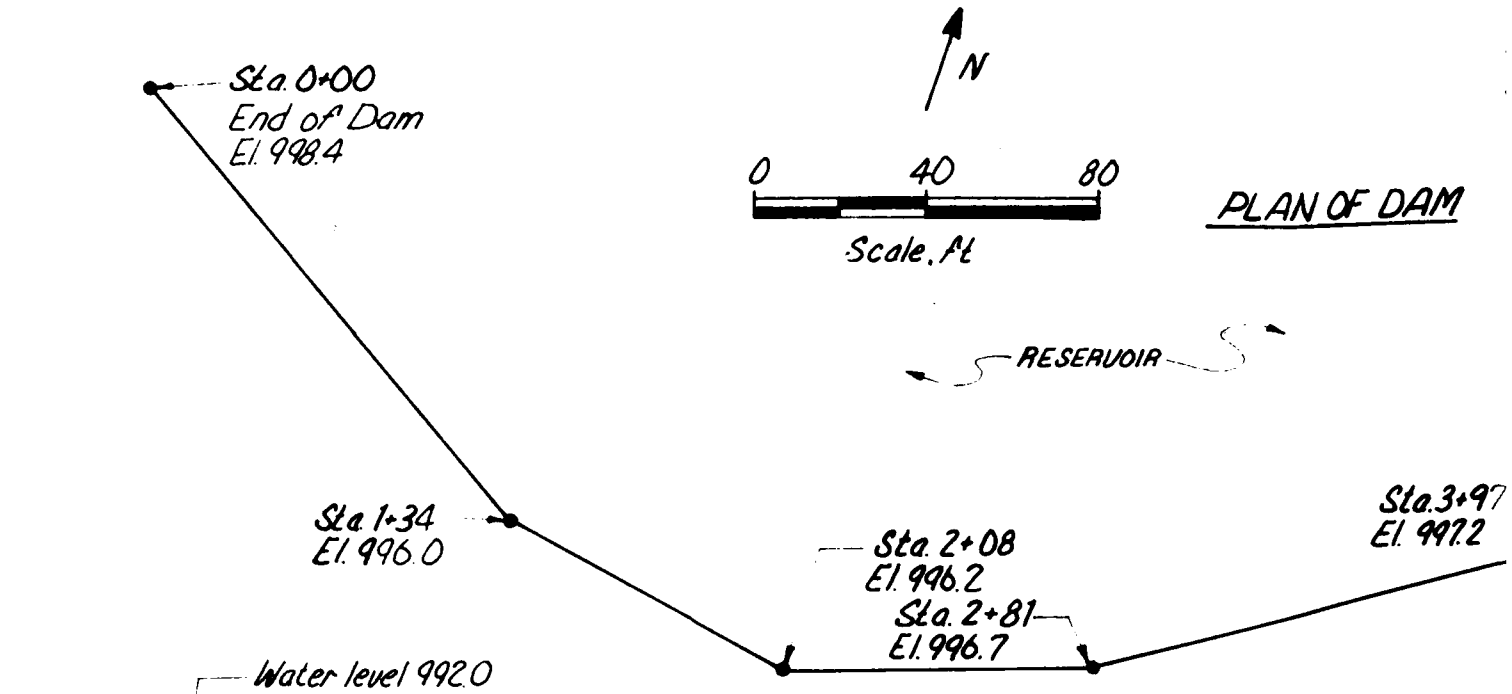
SITE LOCATION MAP	
PINE TREE LAKE WEST DAM	
MO 30995	Fig. 1

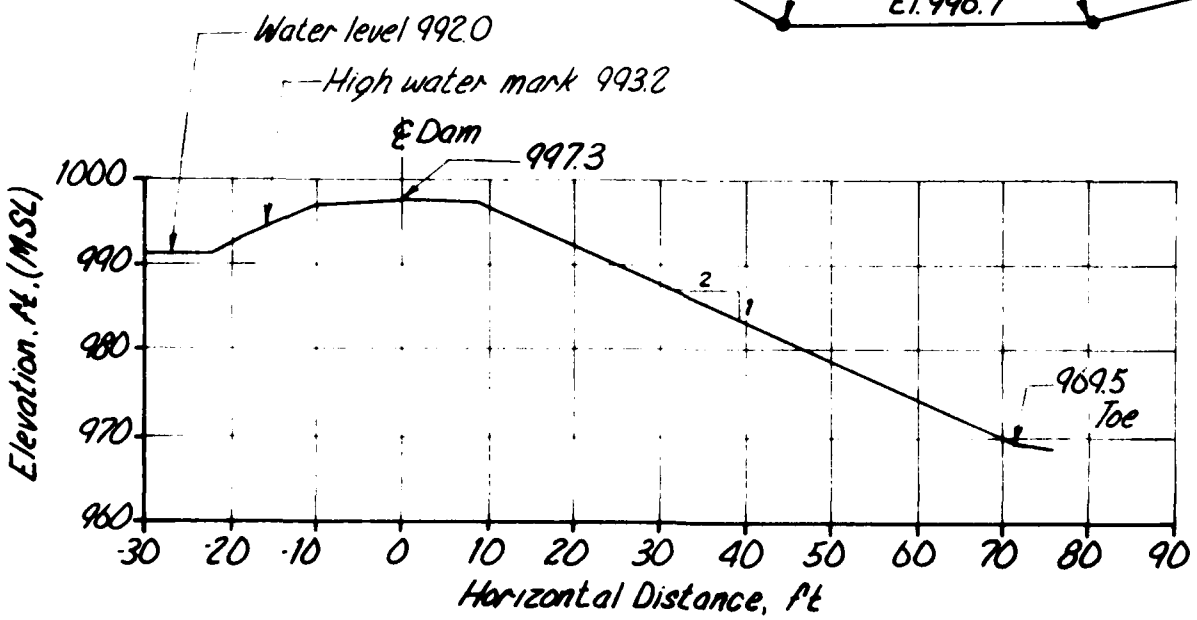


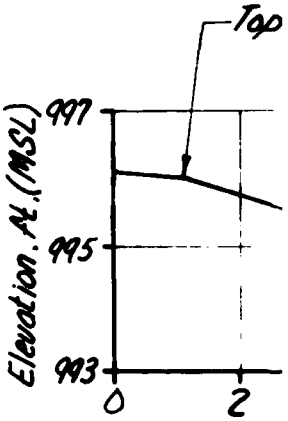
1. Topography from U.S.G.S. Shirley and Potosi 7½ minute quadrangle maps

DRAINAGE BASIN AND SITE TOPOGRAPHY

PINE TREE LAKE WEST DAM	
MO 30995	Fig. 2



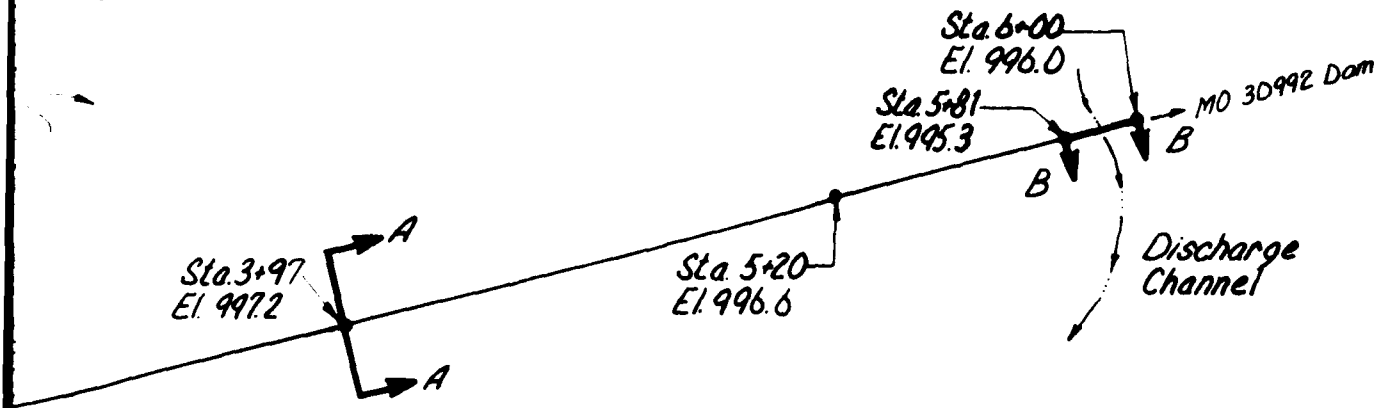


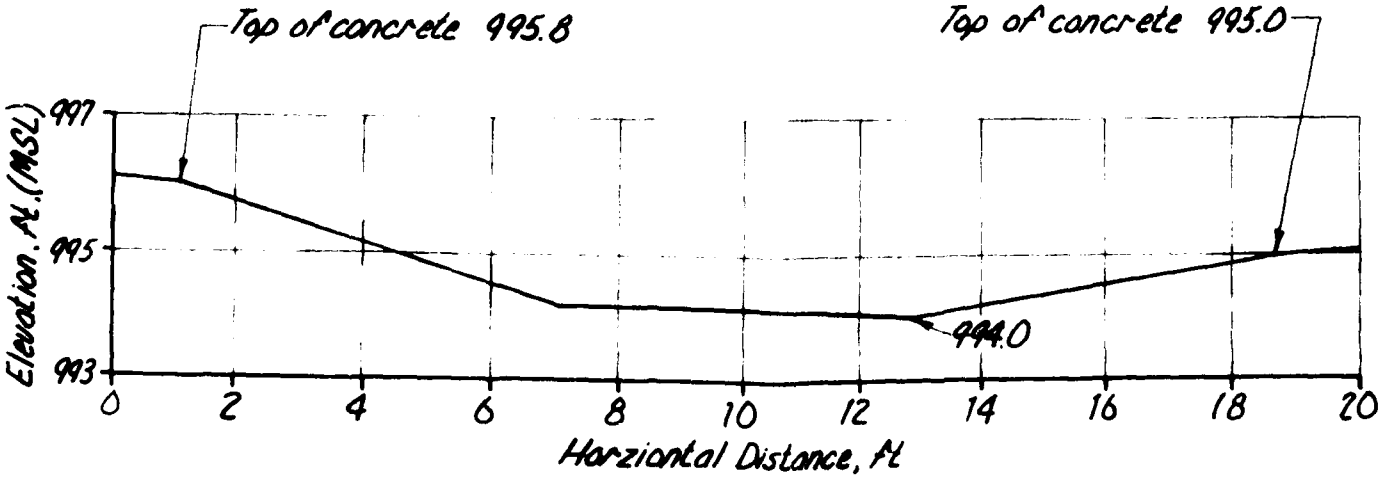


SECTION A-A

Maximum Section

PLAN OF DAM





SECTION B-B
Spillway

NOTES:

1. Common spillway for MO 30995 and MO 30992
2. Section B-B taken at North side of bridge.

PLAN AND SECTION OF DAM AND SPILLWAY SECTION	
PINE TREE LAKE WEST DAMS	
MO 30992	Fig. 3

Legend

Roubidoux Formation

Gasconade Dolomite
Gunter Sandstone Member

Eminence Dolomite

Potosi Dolomite

Derby-Doerun Dolomite

Davis Formation

Bonneterre Formation
Whetstone Creek Member
Sullivan Siltstone Member

Reagan Sandstone
(subsurface, western Missouri)

Lamotte Sandstone

Diabase (dikes and sills)

St. Francois Mountains Intrusive Suite

St. Francois Mountains Volcanic Supergroup

N

0 10 20

Scale, mile

REGIONAL GEOLOGIC MAP

PINE TREE LAKE WEST DAM

MO 30995 | Fig. 4

APPENDIX A

Photographs

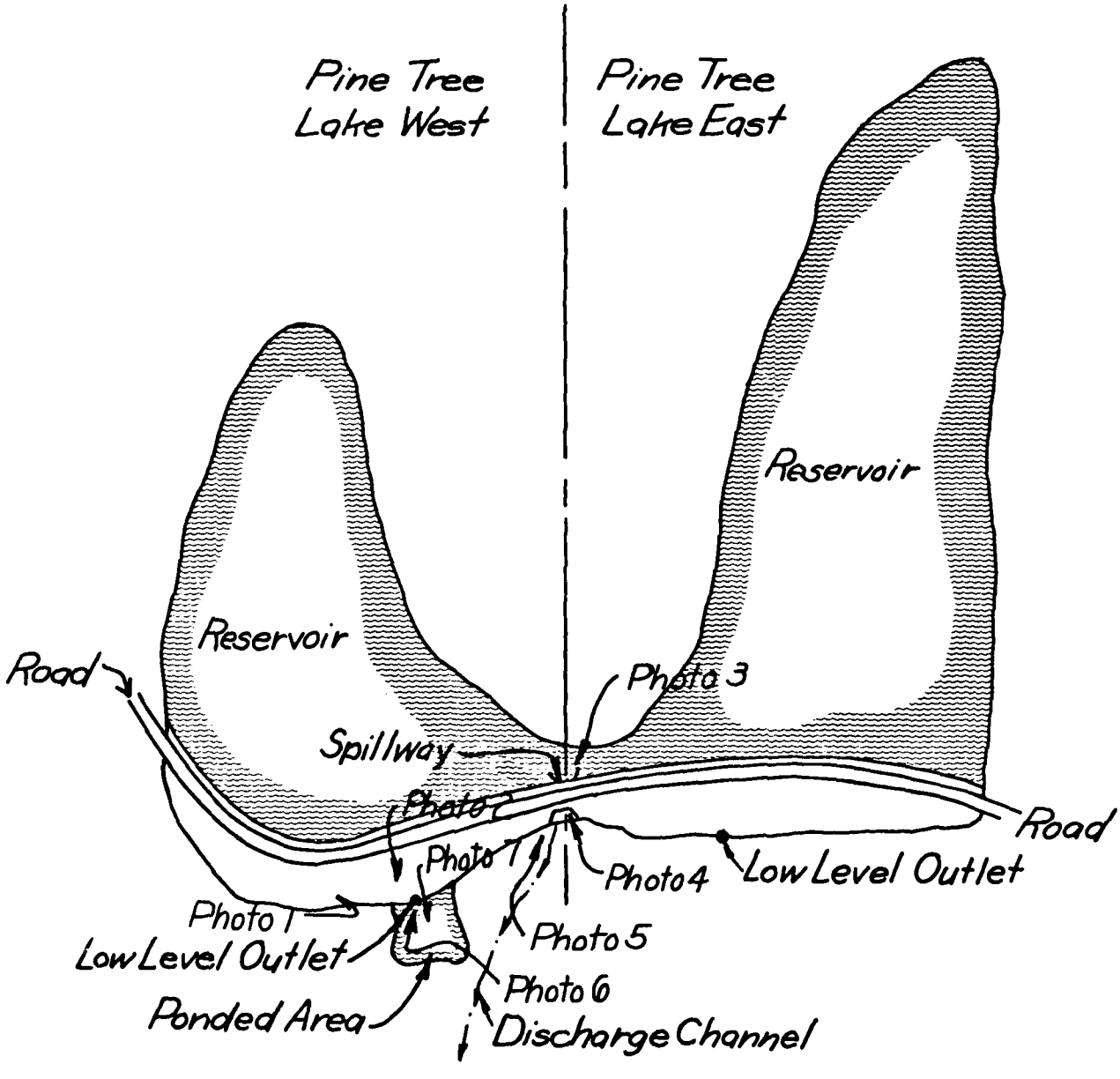
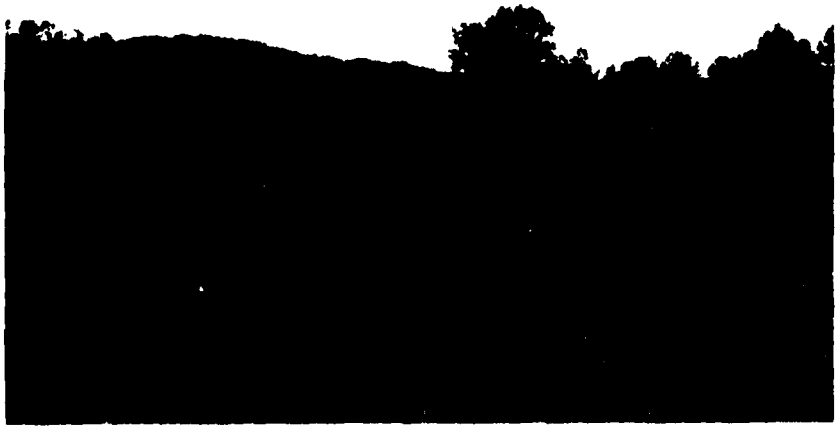


PHOTO LOCATION SKETCH	
PINE TREE LAKE WEST DAM	
MO 30995	Fig. A-1

1. View of downstream slope looking west. Note thick grass cover on slope and erosion channel due to runoff.



2. View downstream from dam crest. Downstream channel flows through trees at left side of picture. Residence at right center is occupied.

3. Approach channel, spillway channel entrance and upstream slope.

4. View of spillway exit looking upstream. Bridge is not fixed and will float off with high flows. Note weir for energy dissipation.

5. Discharge channel looking upstream. Source of water undetermined.

6. Clear flow of about 3 gallons per minute from 4 inches low level outlet at toe of dam.

7. Area of ponded flow from low level outlet at toe of dam.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}(s+1)^{0.7}}{1900\, Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_C \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_C = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF estimates and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - high water mark, el. 993.2

(2) Probable Maximum Storm - spillway crest elevation, el. 994.0

Because the low level outlet pipe is of small diameter, it was assumed that it was inoperable and did not pass any amount of the flood.

f. Spillway Rating Curve. The basic weir equation was utilized to compute the spillway rating curve. The weir equation is as follows:

$$Q = CLH^{3/2}$$

where Q = discharge in cubic feet per second
L = effective length of spillway in feet
C = coefficient of discharge (2.9)
H = total head over spillway in feet

B.2 Pertinent Data

a. Drainage area. 0.15 mi^2

AD-A106 452 WOODWARD-CLYDE CONSULTANTS CHICAGO IL F/G 13/13
NATIONAL DAM SAFETY PROGRAM. PINE TREE LAKE EAST DAM (MO 30992)--ETC(U)
SEP 80 R G BERGGREEN, L M KRAZYNSKI DACW43-80-C-0066
UNCLASSIFIED NL

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.71 hrs

d. Hydrologic soil group. D

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 89
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 77

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Potosi and Shirley 7.5-minute quadrangle maps. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was computed by the intrinsic formula within the HEC-1 program, with pertinent spillway data entered on the $$ cards.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 994.0 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 993.2 ft, the elevation of the high water line in the reservoir area.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********
    1     A1       DAM NO. 30992 AND 30995, PINE TREE LAKES, WASHINGTON COUNTY, MISSOURI.
    2     A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
    3     A3       PROBABLE MAXIMUM FLOOD RATIO FLOODS.
    4     B     288        0       10       -0       -0       -0       -0       -0       -0       -0
    5     B1      5
    6     J       1        4        1
    7     J1    .25      .50      .75     1.00
    8     K       0     Q-IN                                                    1
    9     K1   PINE TREE LAKES PMF RATIO INFLOW HYDROGRAPHS.
   10     M       1        2    0.152                        1                          1
   11     P       0       26.     102.     120.     130.     140.
   12     T                                                                   -1      -89                    .051
   13     W2           0.713
   14     X      -2     -.05        5
   15     K       1      DAM                                                    1
   16     K1   PINE TREE LAKE PMF ROUTING AND OVERTOPPING ANALYSIS.
   17     Y                                        1        1
   18     Y1      1                                                        -994.0        0
   19     SA     0.      1.5      4.5      5.0      5.5      7.0     10.0
   20     SE   974.     980.     990.     992.     994.    1000.    1010.
   21     SS   994.      12.      2.9      1.5
   22     SD 995.3      2.8      1.5
   23     SL     0.      33.     255.     475.
   24     SV 995.3     996.    996.5     997.
   25     K      99
```

Input Data
Various PMF Events
Pine Tree Lake West Dam
MO ID No 30995
B4

Output Summary
Various PMF Events
Pine Tree Lake West Dam
MO ID No 30995
B5

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**********************************
*FLOOD HYDROGRAPH PACKAGE (HEC-1)*
*DAM SAFETY VERSION      JULY 1978*
*  LAST MODIFICATION  01 APR 80  *
**********************************

 RUN  DATE: 02 OCT 80
      TIME: 10.04.23


     DAM NO. 30992 AND 30995, PINE TREE LAKES, WASHINGTON COUNTY, MISSOURI.
     WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
     PROBABLE MAXIMUM FLOOD RATIO FLOODS.

                                  JOB SPECIFICATION
        NQ      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    NSTAN
       288        0       10       -0       -0       -0       -0       -0       -0       -0
                              JOPER      NWT   LROPT   TRACE
                                  5       -0       -0       -0


                          MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1  NRTIO= 4  LRTIO= 1
                  RTIOS=     .25     .50     .75    1.00


                                SUB-AREA RUNOFF COMPUTATION

     PINE TREE LAKES PMF RATIO INFLOW HYDROGRAPHS.

                 ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                 0-IN        0      -0      -0      -0      -0       1      -0      -0

                                 HYDROGRAPH DATA
      IHYDG     IUNG     TAREA     SNAP     TRSDA     TRSPC     RATIO    ISNOW    ISAME    LOCAL
          1        2       .15       -0.       .15      1.00       -0.       -0        1       -0

                                  PRECIP DATA
            SPFE      PMS       R6      R12      R24      R48      R72      R96
              0.    26.00   102.00   120.00   130.00   140.00     -0.      -0.

                                   LOSS DATA
      LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         -0     -0.     -0.    1.00     -0.     -0.    1.00   -1.00  -89.00     -0.     .05

       CURVE NO =  -89.00  WETNESS =   -1.00  EFFECT CN =   89.00

                                UNIT HYDROGRAPH DATA
                             TC= -0.      LAG=   .71

                                 RECESSION DATA
                       STRTQ=   -2.00    QRCSN=    -.05    RTIOR= 5.00

     UNIT HYDROGRAPH 23 END OF PERIOD ORDINATES, TC=   -0.   HOURS, LAG=    .71  VOL= 1.00
```

UNIT HYDROGRAPH DATA
TC= -0. LAG= .71

RECESSION DATA
STRTQ= -2.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 23 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .71 VOL= 1.00

10.	31.	69.	88.	92.	82.	66.	45.	31.	23.
16.	12.	8.	6.	4.	3.	2.	1.	1.	1.
1.	0.	0.							

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	0.	1.02	.10	145	.03	.03	.00	2.
1.01	.20	2	.00	.00	.00	0.	1.02	.20	146	.03	.03	.00	3.
1.01	.30	3	.00	.00	.00	0.	1.02	.30	147	.03	.03	.00	4.
1.01	.40	4	.00	.00	.00	0.	1.02	.40	148	.03	.03	.00	6.
1.01	.50	5	.00	.00	.00	0.	1.02	.50	149	.03	.03	.00	8.
1.01	1.00	6	.00	.00	.00	0.	1.02	1.00	150	.03	.03	.00	10.
1.01	1.10	7	.00	.00	.00	0.	1.02	1.10	151	.03	.03	.00	12.
1.01	1.20	8	.00	.00	.00	0.	1.02	1.20	152	.03	.03	.00	13.
1.01	1.30	9	.00	.00	.00	0.	1.02	1.30	153	.03	.03	.00	13.
1.01	1.40	10	.00	.00	.00	0.	1.02	1.40	154	.03	.03	.00	14.
1.01	1.50	11	.00	.00	.00	0.	1.02	1.50	155	.03	.03	.00	14.
1.01	2.00	12	.00	.00	.00	0.	1.02	2.00	156	.03	.03	.00	15.
1.01	2.10	13	.00	.00	.00	0.	1.02	2.10	157	.03	.03	.00	15.
1.01	2.20	14	.00	.00	.00	0.	1.02	2.20	158	.03	.03	.00	15.
1.01	2.30	15	.00	.00	.00	0.	1.02	2.30	159	.03	.03	.00	15.
1.01	2.40	16	.00	.00	.00	0.	1.02	2.40	160	.03	.03	.00	15.
1.01	2.50	17	.00	.00	.00	0.	1.02	2.50	161	.03	.03	.00	15.
1.01	3.00	18	.00	.00	.00	0.	1.02	3.00	162	.03	.03	.00	15.
1.01	3.10	19	.00	.00	.00	0.	1.02	3.10	163	.03	.03	.00	15.
1.01	3.20	20	.00	.00	.00	0.	1.02	3.20	164	.03	.03	.00	15.
1.01	3.30	21	.00	.00	.00	0.	1.02	3.30	165	.03	.03	.00	15.
1.01	3.40	22	.00	.00	.00	0.	1.02	3.40	166	.03	.03	.00	15.
1.01	3.50	23	.00	.00	.00	0.	1.02	3.50	167	.03	.03	.00	16.
1.01	4.00	24	.00	.00	.00	0.	1.02	4.00	168	.03	.03	.00	16.
1.01	4.10	25	.00	.00	.00	0.	1.02	4.10	169	.03	.03	.00	16.
1.01	4.20	26	.00	.00	.00	0.	1.02	4.20	170	.03	.03	.00	16.
1.01	4.30	27	.00	.00	.00	0.	1.02	4.30	171	.03	.03	.00	16.
1.01	4.40	28	.00	.00	.00	0.	1.02	4.40	172	.03	.03	.00	16.
1.01	4.50	29	.00	.00	.00	0.	1.02	4.50	173	.03	.03	.00	16.
1.01	5.00	30	.00	.00	.00	0.	1.02	5.00	174	.03	.03	.00	16.
1.01	5.10	31	.00	.00	.00	0.	1.02	5.10	175	.03	.03	.00	16.
1.01	5.20	32	.00	.00	.00	0.	1.02	5.20	176	.03	.03	.00	16.
1.01	5.30	33	.00	.00	.00	0.	1.02	5.30	177	.03	.03	.00	16.
1.01	5.40	34	.00	.00	.00	0.	1.02	5.40	178	.03	.03	.00	16.
1.01	5.50	35	.00	.00	.00	0.	1.02	5.50	179	.03	.03	.00	16.
1.01	6.00	36	.00	.00	.00	0.	1.02	6.00	180	.03	.03	.00	16.
1.01	6.10	37	.01	.00	.01	0.	1.02	6.10	181	.13	.12	.01	17.
1.01	6.20	38	.01	.00	.01	0.	1.02	6.20	182	.13	.12	.01	20.
1.01	6.30	39	.01	.00	.01	0.	1.02	6.30	183	.13	.12	.01	26.
1.01	6.40	40	.01	.00	.01	0.	1.02	6.40	184	.13	.12	.01	34.
1.01	6.50	41	.01	.00	.01	0.	1.02	6.50	185	.13	.12	.01	43.
1.01	7.00	42	.01	.00	.01	0.	1.02	7.00	186	.13	.12	.01	51.
1.01	7.10	43	.01	.00	.01	0.	1.02	7.10	187	.13	.12	.01	57.
1.01	7.20	44	.01	.00	.01	0.	1.02	7.20	188	.13	.12	.01	62.
1.01	7.30	45	.01	.00	.01	0.	1.02	7.30	189	.13	.12	.01	65.
1.01	7.40	46	.01	.00	.01	0.	1.02	7.40	190	.13	.12	.01	67.
1.01	7.50	47	.01	.00	.01	0.	1.02	7.50	191	.13	.12	.01	69.
1.01	8.00	48	.01	.00	.01	0.	1.02	8.00	192	.13	.12	.01	70.
1.01	8.10	49	.01	.00	.01	0.	1.02	8.10	193	.13	.13	.00	71.
1.01	8.20	50	.01	.00	.01	0.	1.02	8.20	194	.13	.13	.00	72.

Output Summary
Various PMF Events
Pine Tree Lake West Dam
MO ID No 30995
B6

Output Summary
Various PMF Events
Pine Tree Lake West Dam
MO ID No 30995
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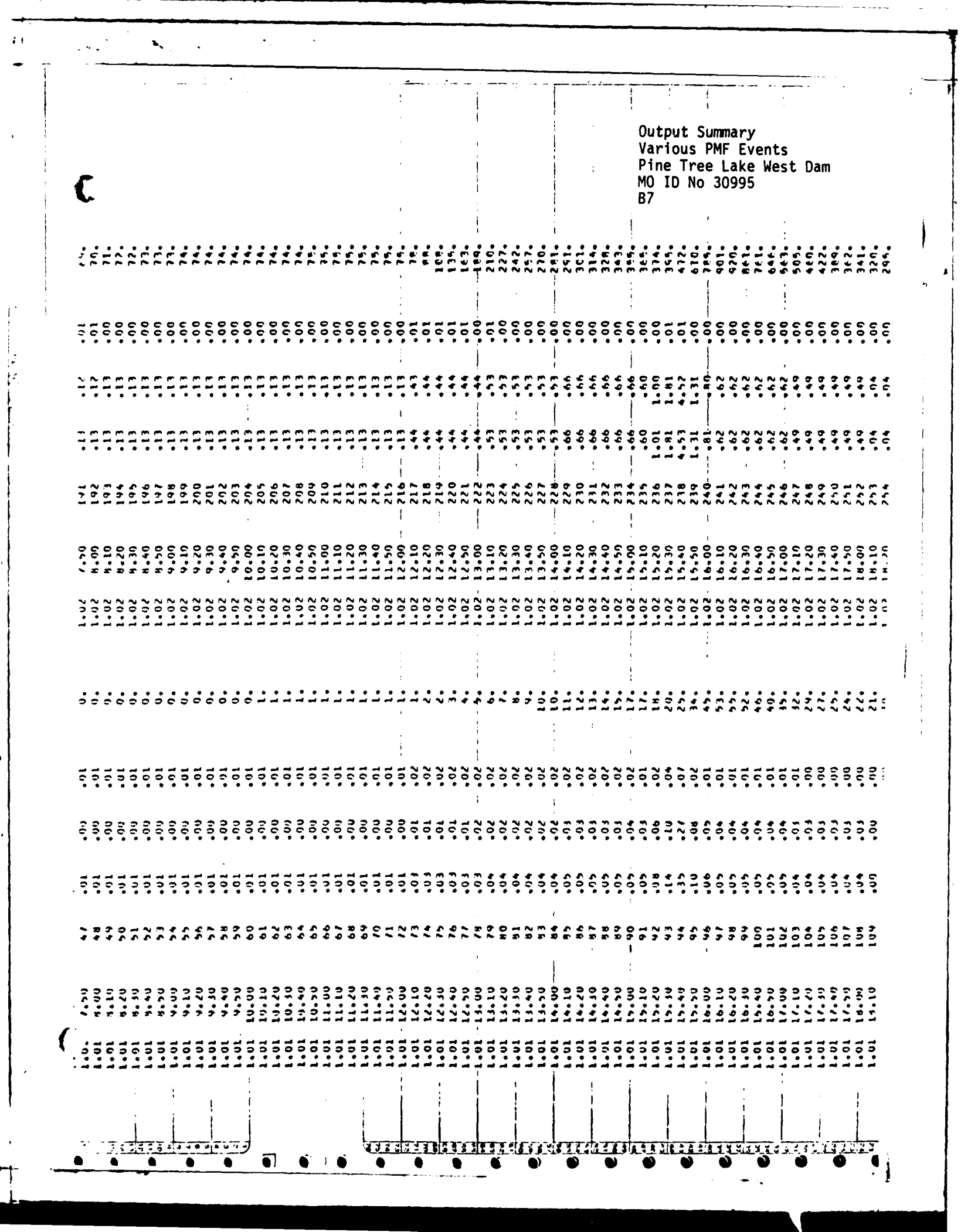

Output Summary
Various PMF Events
Pine Tree Lake West Dam
MO ID No 30995
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1.01	14.40	88	.05	.03	.02	14.	1.02	14.40	232	.66	.65	.00	328.
1.01	14.50	89	.05	.03	.02	15.	1.02	14.50	233	.66	.66	.00	343.
1.01	15.00	90	.05	.04	.02	17.	1.02	15.00	234	.66	.66	.00	355.
1.01	15.10	91	.05	.03	.01	17.	1.02	15.10	235	.60	.60	.00	365.
1.01	15.20	92	.08	.06	.02	18.	1.02	15.20	236	1.01	1.00	.00	374.
1.01	15.30	93	.14	.10	.04	20.	1.02	15.30	237	1.81	1.81	.01	395.
1.01	15.40	94	.35	.27	.07	25.	1.02	15.40	238	4.53	4.52	.01	472.
1.01	15.50	95	.10	.08	.02	34.	1.02	15.50	239	1.31	1.31	.00	610.
1.01	16.00	96	.06	.05	.01	45.	1.02	16.00	240	.81	.80	.00	785.
1.01	16.10	97	.05	.04	.01	53.	1.02	16.10	241	.62	.62	.00	901.
1.01	16.20	98	.05	.04	.01	55.	1.02	16.20	242	.62	.62	.00	920.
1.01	16.30	99	.05	.04	.01	52.	1.02	16.30	243	.62	.62	.00	861.
1.01	16.40	100	.05	.04	.01	46.	1.02	16.40	244	.62	.62	.00	761.
1.01	16.50	101	.05	.04	.01	40.	1.02	16.50	245	.62	.62	.00	646.
1.01	17.00	102	.05	.04	.01	35.	1.02	17.00	246	.62	.62	.00	563.
1.01	17.10	103	.04	.03	.01	32.	1.02	17.10	247	.49	.49	.00	505.
1.01	17.20	104	.04	.03	.00	29.	1.02	17.20	248	.49	.49	.00	460.
1.01	17.30	105	.04	.03	.00	27.	1.02	17.30	249	.49	.49	.00	422.
1.01	17.40	106	.04	.03	.00	25.	1.02	17.40	250	.49	.49	.00	389.
1.01	17.50	107	.04	.03	.00	24.	1.02	17.50	251	.49	.49	.00	362.
1.01	18.00	108	.04	.03	.00	22.	1.02	18.00	252	.49	.49	.00	341.
1.01	18.10	109	.00	.00	.00	21.	1.02	18.10	253	.04	.04	.00	320.
1.01	18.20	110	.00	.00	.00	20.	1.02	18.20	254	.04	.04	.00	295.
1.01	18.30	111	.00	.00	.00	17.	1.02	18.30	255	.04	.04	.00	258.
1.01	18.40	112	.00	.00	.00	14.	1.02	18.40	256	.04	.04	.00	214.
1.01	18.50	113	.00	.00	.00	11.	1.02	18.50	257	.04	.04	.00	169.
1.01	19.00	114	.00	.00	.00	9.	1.02	19.00	258	.04	.04	.00	130.
1.01	19.10	115	.00	.00	.00	7.	1.02	19.10	259	.04	.04	.00	98.
1.01	19.20	116	.00	.00	.00	5.	1.02	19.20	260	.04	.04	.00	77.
1.01	19.30	117	.00	.00	.00	4.	1.02	19.30	261	.04	.04	.00	61.
1.01	19.40	118	.00	.00	.00	3.	1.02	19.40	262	.04	.04	.00	51.
1.01	19.50	119	.00	.00	.00	3.	1.02	19.50	263	.04	.04	.00	44.
1.01	20.00	120	.00	.00	.00	3.	1.02	20.00	264	.04	.04	.00	38.
1.01	20.10	121	.00	.00	.00	2.	1.02	20.10	265	.04	.04	.00	34.
1.01	20.20	122	.00	.00	.00	2.	1.02	20.20	266	.04	.04	.00	32.
1.01	20.30	123	.00	.00	.00	2.	1.02	20.30	267	.04	.04	.00	30.
1.01	20.40	124	.00	.00	.00	2.	1.02	20.40	268	.04	.04	.00	28.
1.01	20.50	125	.00	.00	.00	2.	1.02	20.50	269	.04	.04	.00	27.
1.01	21.00	126	.00	.00	.00	2.	1.02	21.00	270	.04	.04	.00	27.
1.01	21.10	127	.00	.00	.00	2.	1.02	21.10	271	.04	.04	.00	26.
1.01	21.20	128	.00	.00	.00	2.	1.02	21.20	272	.04	.04	.00	26.
1.01	21.30	129	.00	.00	.00	2.	1.02	21.30	273	.04	.04	.00	26.
1.01	21.40	130	.00	.00	.00	2.	1.02	21.40	274	.04	.04	.00	26.
1.01	21.50	131	.00	.00	.00	2.	1.02	21.50	275	.04	.04	.00	25.
1.01	22.00	132	.00	.00	.00	2.	1.02	22.00	276	.04	.04	.00	25.
1.01	22.10	133	.00	.00	.00	2.	1.02	22.10	277	.04	.04	.00	25.
1.01	22.20	134	.00	.00	.00	2.	1.02	22.20	278	.04	.04	.00	25.
1.01	22.30	135	.00	.00	.00	2.	1.02	22.30	279	.04	.04	.00	25.
1.01	22.40	136	.00	.00	.00	2.	1.02	22.40	280	.04	.04	.00	25.
1.01	22.50	137	.00	.00	.00	2.	1.02	22.50	281	.04	.04	.00	25.
1.01	23.00	138	.00	.00	.00	2.	1.02	23.00	282	.04	.04	.00	25.
1.01	23.10	139	.00	.00	.00	2.	1.02	23.10	283	.04	.04	.00	25.
1.01	23.20	140	.00	.00	.00	2.	1.02	23.20	284	.04	.04	.00	25.
1.01	23.30	141	.00	.00	.00	2.	1.02	23.30	285	.04	.04	.00	25.
1.01	23.40	142	.00	.00	.00	2.	1.02	23.40	286	.04	.04	.00	25.
1.01	23.50	143	.00	.00	.00	2.	1.02	23.50	287	.04	.04	.00	25.
1.02	0.	144	.00	.00	.00	2.	1.03	0.	288	.04	.04	.00	25.
									SUM	36.40	35.03	1.37	20467.
										(925.)(	890.)(	35.)(	579.56)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	920.	417.	136.	71.	20464.
					579.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS			
OPERATION	STATION	AREA	PLAN	RATIO 1 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	U-IN	.15	1	230.	460.	690.	920.
		(.39)	(	6.51)(	13.03)(	19.54)(	26.05)(
ROUTED TO	DAM	.15	1	212.	457.	690.	921.
		(.39)	(	5.99)(	12.93)(	19.53)(	26.09)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	994.00	994.00	995.30
	STORAGE	52.	52.	59.
	OUTFLOW	0.	0.	52.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	996.33	1.03	65.	212.	5.00	40.50	0.
.50	996.68	1.38	67.	457.	7.00	40.33	0.
.75	996.87	1.57	68.	690.	10.00	40.33	0.
1.00	997.03	1.73	69.	921.	12.33	40.33	0.

Output Summary
Various PMF Events
Pine Tree Lake West Dam
MO ID No 30995
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .06	RATIO 2 .07	RATIO 3 .08	RATIO 4 .09
				RATIOS APPLIED TO FLOWS			
HYDROGRAPH AT	D-IN	.15	1	55.	64.	74.	83.
		(.39)		(1.56)(	(1.82)(	(2.08)(	(2.34)(
ROUTED TO	DAM	.15	1	33.	39.	46.	53.
		(.39)		(.94)(	(1.12)(	(1.30)(	(1.49)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	994.00	994.00	995.30
	STORAGE	52.	52.	59.
	OUTFLOW	0.	0.	52.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.06	994.97	0.	57.	33.	0.	41.00	0.
.07	995.09	0.	58.	39.	0.	41.00	0.
.08	995.20	0.	58.	46.	0.	41.00	0.
.09	995.32	.02	59.	53.	.50	41.00	0.

Output Summary
Equivalent PMF Analyses
Pine Tree Lake West Dam
MO ID No 30995
B10

END

DATE
FILMED
12-81

DTIC